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AVIATION AND AERONAUTICAL ENGINEERING

British Observation Balloon on the Italian Front
British Official, from Feature Photo Service

VOLUME V
Number 5

SPECIAL FEATURES

LIMIT PERFORMANCE OF AIRPLANES
SOME NEW ENEMY AIRPLANES
THE CLIMB OF AN AIRPLANE
COST OF AIR MAIL SERVICE
SYNTHETIC GASOLINE

Two Dollars a Year

PUBLISHED SEMI-MONTHLY
BY
THE GARDNER-MOFFAT CO., INC.
120 WEST 32nd ST. NEW YORK

Entered as second-class matter, August 5, 1916, at the Post Office at New York, N. Y., under act of March 3, 1879

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TRADE MARK

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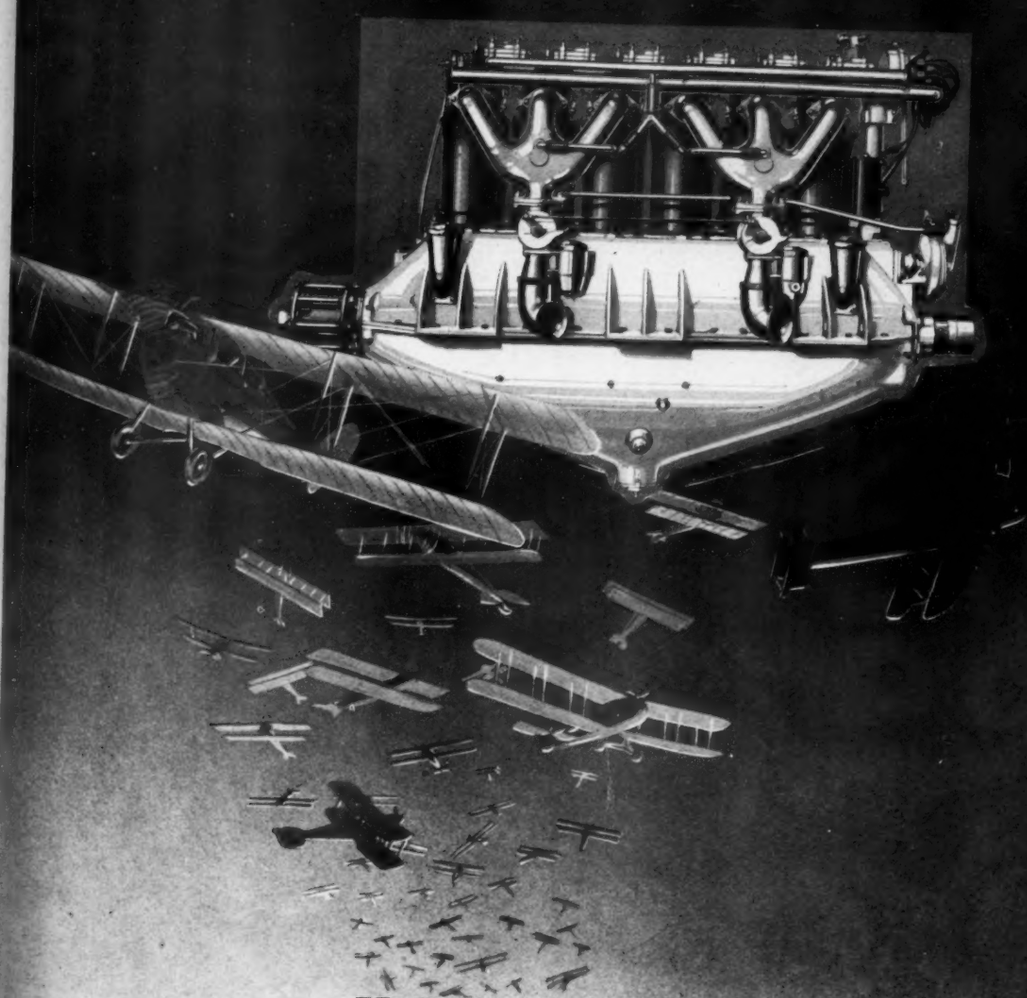

Hall-Scott L-6 Engine
Shows Remarkable Test Record

In test runs at the Dayton Engineering Laboratories (Delco) with a Hall-Scott, six cylinder, L-6 Airplane Engine, the average b. h. p. developed was 212.6 at 1666 r. p. m. This engine weighed on the test stand, 502 lbs., or 2.45 lbs. per b. h. p.

The well known Hall-Scott type A-5 Engine, rated at 125 h. p., weight 4.12 lbs. per b. h. p., is still a successful product. The L-6 is a fighting job showing marked development advance.

Circular on request.

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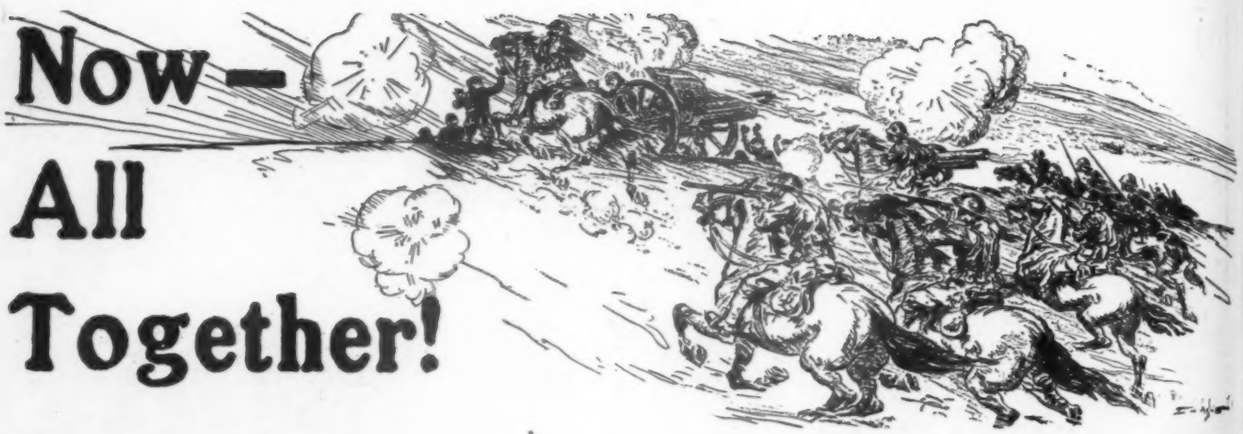
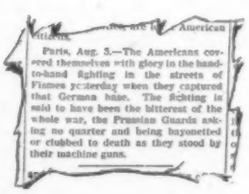


NOTHING could stand against the mad dash of the French and American cavalry on the Marne—the German lines gave way, broke, fled; the day was won.

That fighting spirit of the men of Foch and Pershing, that united purpose—for Victory—*must be the spirit, the purpose, of each of us behind the lines.*



Paris, Aug. 3.—The Americans covered themselves with glory in the hand-to-hand fighting in the streets of Flamez yesterday when they captured that Germa base. The fighting is said to have been the bitterest of the whole war, the Prussian Guards neiling no quarter and being bayonetted or clubbed to death as they stood by their machine guns.

We must lend as well as they fight. And we must pull together with all the strength we have—*now!*

We must so order our lives that we can save—to the limit—and lend—to the limit—for Victory. We must put America's whole strength behind our fighting men.

Now—All Together!

Let us lend the way they fight ***Let us buy bonds to our utmost***

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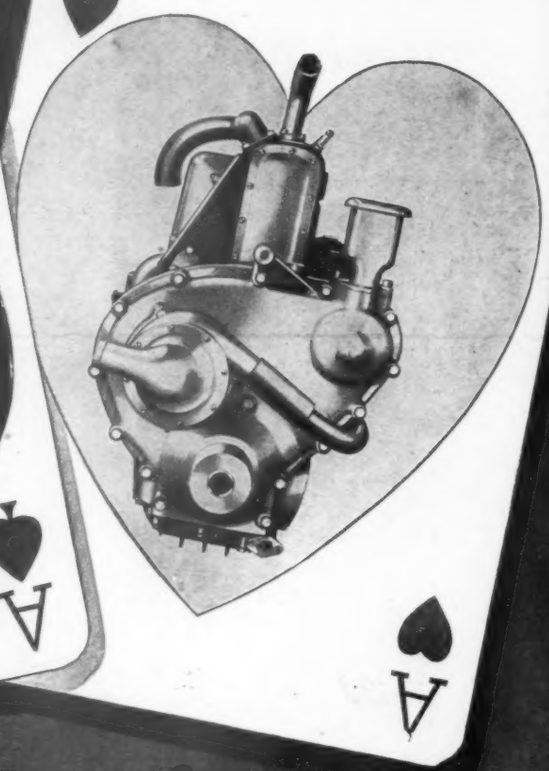
"The Birthplace of the Airplane"

A Pair of Aces



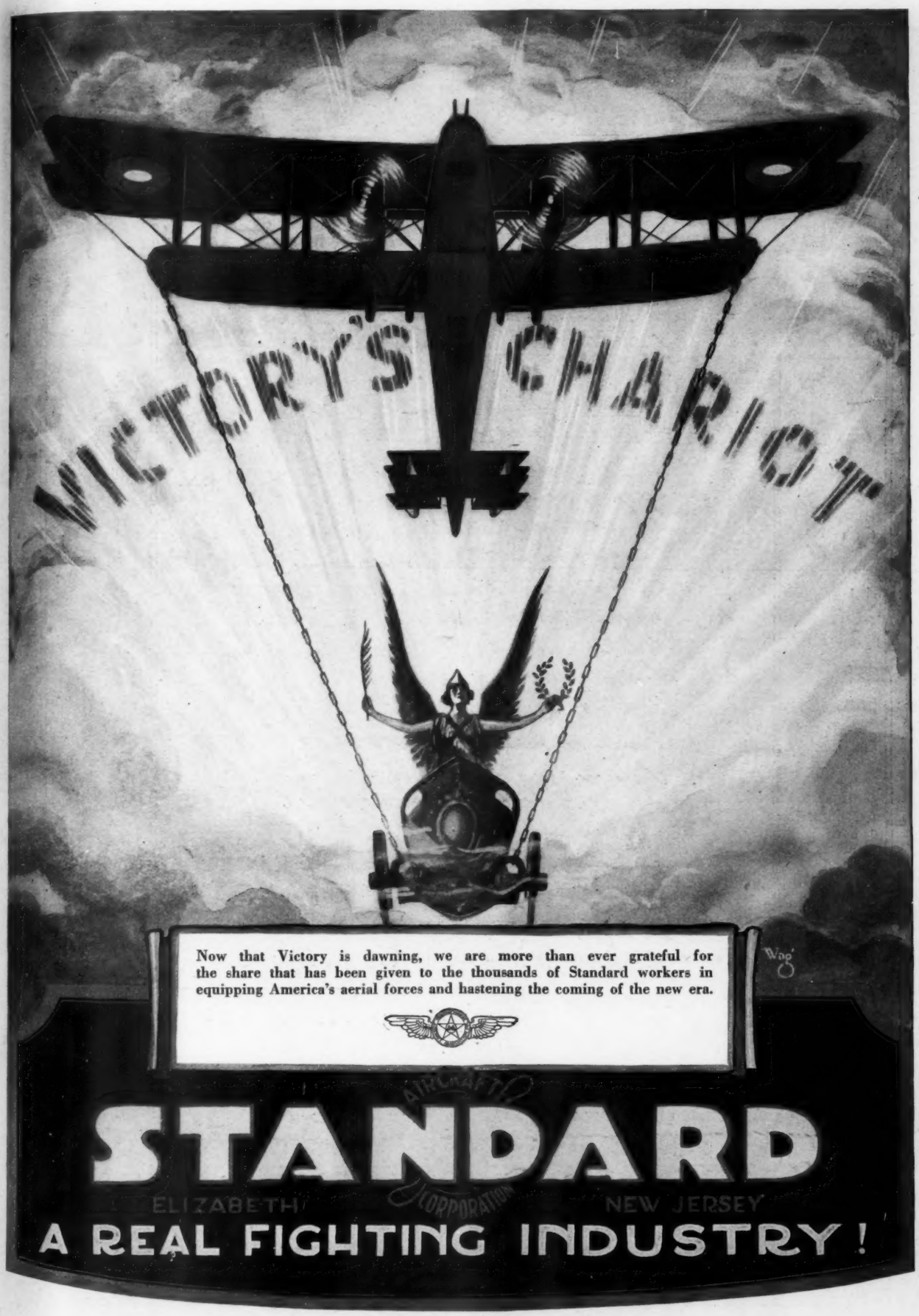
Eddie Rickenbacher and the Duesenberg Motor

LIEUT. "EDDIE" RICKENBACHER in pre-war days used Duesenberg engines in his spectacular feats on the automobile race tracks of America. Today, Lieut. Rickenbacher is creating even more renown for himself as an "Ace" over there whilst the entire facilities of the Duesenberg Organization are devoted to building aviation engines over here.

What are you going to do for the Fourth Liberty Loan?

DUESENBERG MOTORS CORPORATION, 120 BROADWAY, NEW YORK CITY

Contractors to the United States Government

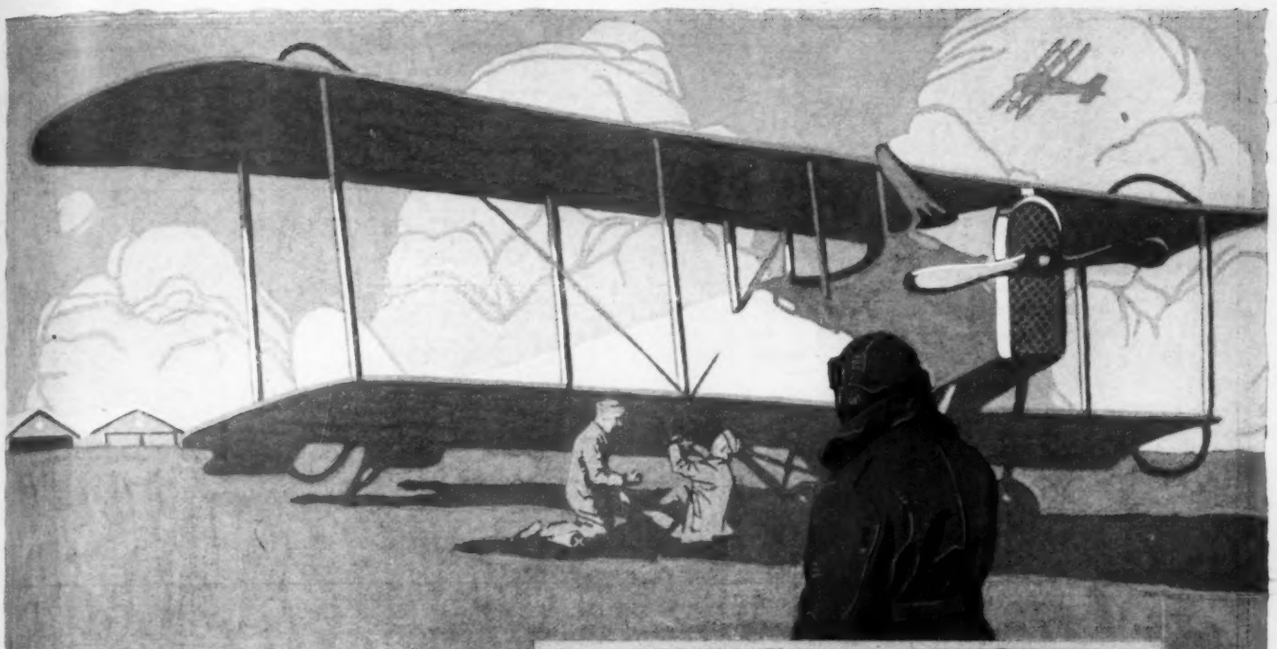

VICTORY'S CHARIOT
Now that Victory is dawning, we are more than ever grateful for the share that has been given to the thousands of Standard workers in equipping America's aerial forces and hastening the coming of the new era.
AIRCRAFT
STANDARD
CORPORATION
ELIZABETH NEW JERSEY
A REAL FIGHTING INDUSTRY!

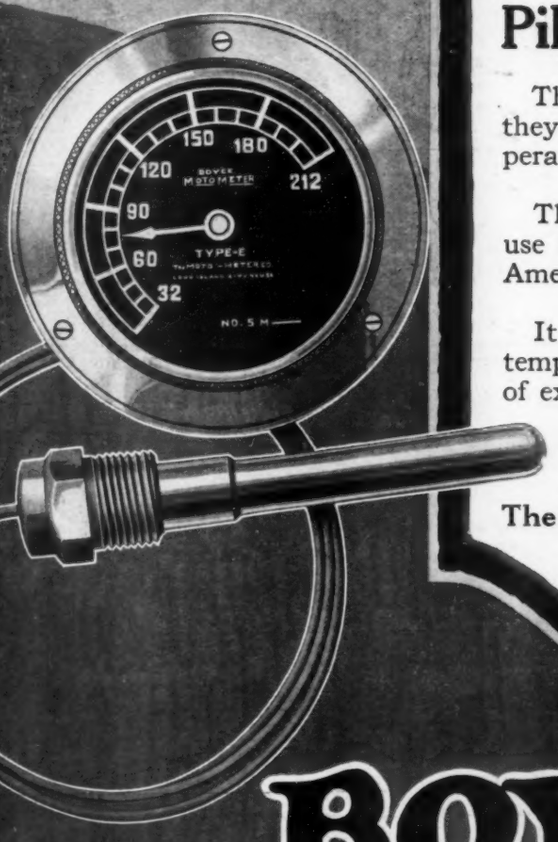
THE WHITE HOUSE
WASHINGTON

Again the Government comes to the people of the country with the request that they lend their money, and lend it upon a more liberal scale than ever before, in order that the great war for the rights of America and the liberation of the world may be prosecuted with ever increasing vigor to a victorious conclusion. And it makes the appeal with the greatest confidence because it knows that every day it is becoming clearer and clearer to thinking men throughout the nation that the conquering of the war is an essential investment. The money that is held back now will be of little use or value if the war is not won and the selfish masters of Germany are permitted to dictate what America may and may not do. Men in America, besides, have from the first unto now dedicated both their lives and their fortunes to the vindication and maintenance of the great principles and objects for which our Government was set up. They will not fail now to show the world for what their wealth was intended.

Woodrow Wilson

This Space Contributed to Winning the War by
BOEING AIRPLANE COMPANY, SEATTLE, WASHINGTON





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That is the reason for the universal use of the Boyce Moto-Meter upon American war-planes.

It tells the pilot the *exact* motor temperature at all altitudes, regardless of extremes of weather or climate; it registers accurately every degree from boiling to freezing.

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4200 lbs.	1/4" Round	.29	4800 lbs.	2 1/2" Round	.23
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5000 "	3/8" "	.32	1500 "	3" "	.21
500 "	7/16"" "	.30	34000 "	5/16" Hexagon	.31
36000 "	1/2" "	.31	7500 "	3/8" "	.30
40000 "	3/4" "	.32	20000 "	7/16" "	.29
5000 "	1 1/8"" "	.25	17000 "	1/2" "	.33
14000 "	1 3/16" "	.23	11000 "	5/8" "	.30
39000 "	1 1/4" "	.23	4000 "	11/16" "	.22
20000 "	1 3/8" "	.21	15000 "	7/8" "	.35
6200 "	1 5/8" "	.19	8300 "	1" "	.25
9600 "	2 1/4" "	.18	1400 "	1 7/16" "	.30

HOT ROLLED 3½% NICKEL .15 to .25 CARBON

24000 lbs.	1/2" Round	9700 lbs.	2" Round
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5200 "	1 13/16" "	60000 "	3 3/16" "

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12600 "	3/16" "	7000 "	11/16" "	4500 "	1 3/8" "
36000 "	1/4" "	41500 "	3/4" "	25000 "	1 5/8" "
8500 "	9/32" "	26000 "	13/16" "	20000 "	1 11/16" "
11000 "	5/16" "	49000 "	7/8" "	25000 "	1 3/4" "
7500 "	11/32" "	3000 "	57/64" "	15000 "	2 1/16" "
53000 "	3/8" "	21000 "	15/16" "	23000 "	2 1/8" "
19000 "	7/16" "	10500 "	1 1/16" "	4000 "	3" "
16000 "	1/2" "	11000 "	1 1/8" "	5800 "	4 7/8" "
		7200 "	1 15/64" "		

HEXAGONS HEXAGONS HEXAGONS

"ACME" FREE CUTTING SCREW STOCK

240000 lbs.	7/16"	15000 lbs.	3/4"	1000 lbs.	1 1/16"
13000 "	1/2"	3000 "	13/16"	35000 "	1 1/8"
20000 "	9/16"	3000 "	13/16"	55000 "	1 1/4"
13000 "	5/8"	10000 "	7/8"	15000 "	1 5/16"
25000 "	11/16"	1000 "	15/16"	1500 "	1 1/2"

SQUARES SQUARES SQUARES

750 lbs.	3/16"	5100 lbs.	1/2"	1000 lbs.	15/16"
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All of the material listed above offered subject to prior sale from our Cleveland warehouse. The only orders that we will entertain or consider will be from concerns that require this material for United States Government work and can supply us with the necessary information in the way of Government order numbers, priority certificates, etc.

The Betz-Pierce Co.
Cleveland, Ohio

CHICAGO DAYTON DETROIT INDIANAPOLIS PITTSBURGH

Dollars that Fight

By SENATOR HENRY CABOT LODGE

The war will be won by men and ships, by guns and airplanes. To raise armies and supply them, to build the navy and support it, and to furnish ships and transport, we must have money in large amounts. The expenditures of the Government for the ensuing year are estimated at $24,000,000,000, a sum which baffles the imagination to conceive. That vast amount must come one-third from taxes and two-thirds from loans. The success of the Fourth Loan, like those that preceded it is, therefore, absolutely necessary. We must work with the highest speed, as if the war was to end in six months. We must prepare in every direction, as if it was to last for years. Speed and preparation are both expensive.

Without the Loans We Cannot Have Either

We are fighting to secure a just, righteous and lasting peace. For a complete peace we must have a complete victory. It must not be a peace of bargain or negotiation. No peace which satisfies Germany can ever satisfy us. No peace that leaves Germany in a position to renew the war against us will be worth having. It will be far from sufficient to gain all our objects on the Western front—Belgium, Alsace-Lorraine, Italia Irredenta. The President with wisdom and foresight and great force expressed his determination to redeem Russia. Russia must not be left in Germany's hands. That would mean another war. Poland must be free. Slav republics must be established to bar the way between Germany and the East. Serbia and Roumania must be redeemed. All these things are essential. *Nothing will bring them but complete victory and a peace dictated by us and our allies.* It is a conflict of ideas. It is the principle of evil arrayed against the principle of good. It is the battle of freedom and civilization against barbarism and tyranny. *We must win and we shall win.*

We Cannot Win Without Money, and, Therefore, These Loans Are Vital, and the Country Should Rally in All Its Strength and Subscribe and Oversubscribe the Fourth Loan

Buy Bonds to Your Utmost!

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SPERRY GYROSCOPE COMPANY, BROOKLYN, NEW YORK

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The Steel Products Co.

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Cleveland, Ohio

Rout 'em Out!

That's what Pershing's men are doing to the Huns. Not just stopping 'em, but chasing 'em—cleaning them out like rats from the house. The Americans are *fighting with their whole souls.*

That's the way to Fight

When you mean to win—rout 'em out! Go get every dollar you can afford—yes, and more—to lend the good old U. S. Government to back up Our Boys in the fight. Rout 'em out! Not only your own dollars, but rout out every man, woman and child you know and make them buy Liberty Bonds.

Buy Liberty Bonds to Your UTMOST

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Elias Buegeleisen, Sole Proprietor
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For Oil, Natural Gas or Manufactured Gas

S-C-H Furnace No. 5-A

Seven kinds of usefulness

(1) ANNEALING
(2) CASE-HARDENING
(3) DRESSING TOOLS
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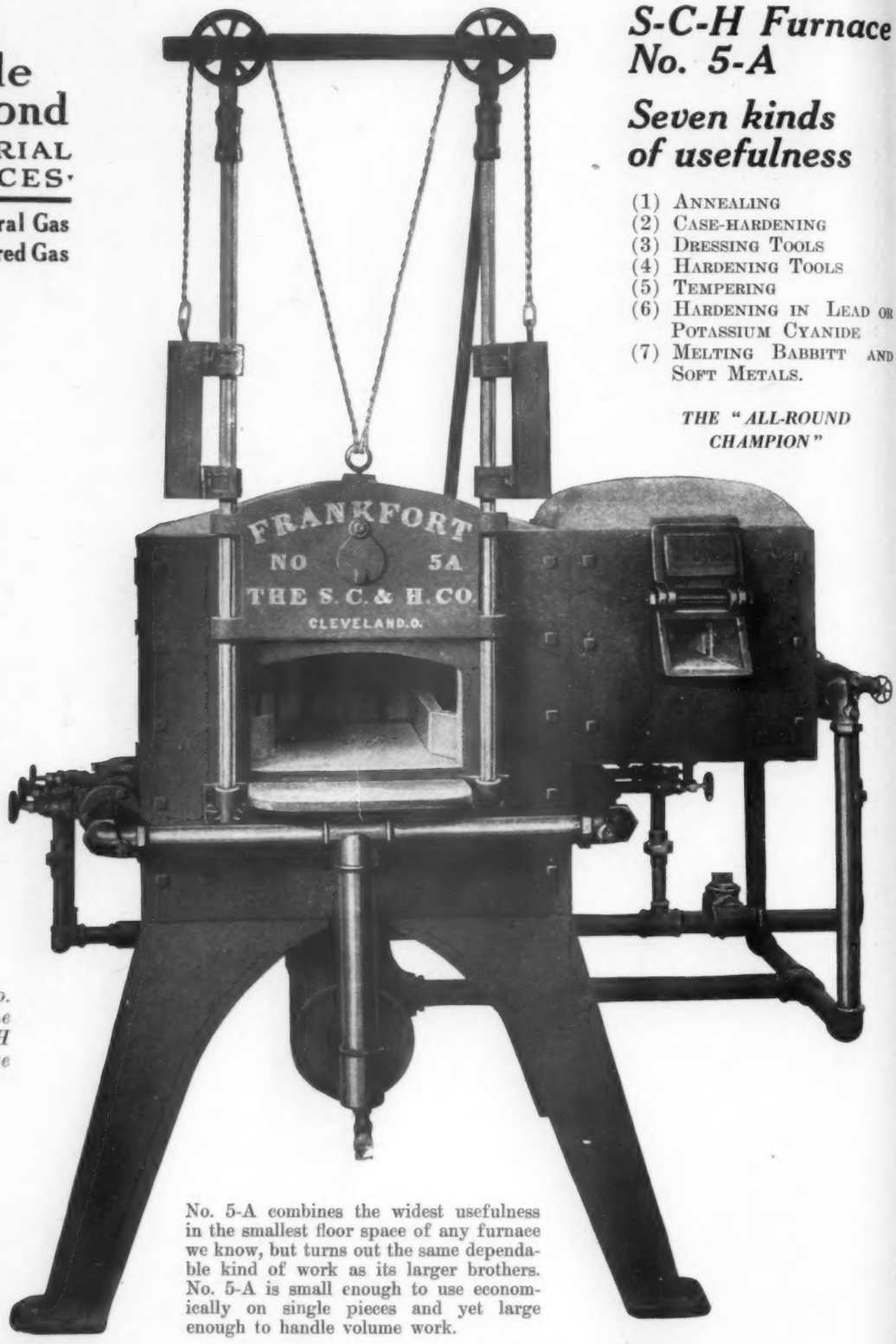
(5) TEMPERING
(6) HARDENING IN LEAD OR POTASSIUM CYANIDE
(7) MELTING BABBITT AND SOFT METALS.

THE "ALL-ROUND CHAMPION"



Send for catalog No. 8-B describing the full line of 75 S-C-H furnaces—a furnace for every purpose.

No. 5-A combines the widest usefulness in the smallest floor space of any furnace we know, but turns out the same dependable kind of work as its larger brothers. No. 5-A is small enough to use economically on single pieces and yet large enough to handle volume work.

The two ovens and melting pot are served by separate burners working independently of each other. A high or low temperature can be secured which makes it invaluable for high speed steel. The melting pot will hold about 75 pounds of lead or babbitt, and any temperature may be obtained and held. Write for detailed specifications.

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SO wrote one of America's most prominent manufacturers of printing machinery.

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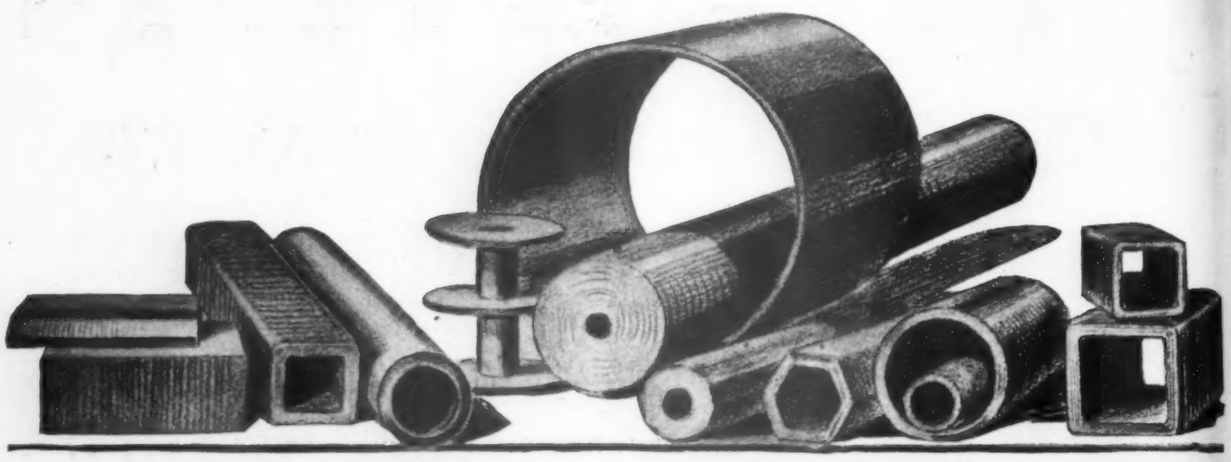

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Fires Two Plugs in Each Cylinder with Perfect Synchronism

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"Triplex Double" Ignition

Important Advantages

1—Three separate systems of engine ignition.

2—Two independent Single Spark Systems.

3—One High Frequency or Emergency System.

4—Current to both distributors fed through one Contact Maker.

5—Practical impossibility of ignition failure.

6—Efficiency of the Philbrin Armored Condenser.

IN designing this system for double ignition engines, particular attention was given to the problem of spark synchronism and security against ignition failure. The problem's solution is found in the system's simplicity as described below.

1—Philbrin Triplex Double Ignition embodies three separate systems—two Single Spark systems, which can be used interchangeably, and one High Frequency or Emergency system.

2—Each Single Spark system is efficient at all engine speeds and under highest compression. It owes this efficiency to the design of the Philbrin Contact Maker which provides for thorough saturation of the coil and an instantaneous break.

3—The High Frequency system delivers a "shower of sparks" to each cylinder in its regular firing order and uses the same pair of distributors as the Single Spark systems. Quick and easy starting are secured by this "shower of sparks" which will fire any ignitable mixture and supplies perfect combustion under adverse conditions—such as a flooded carburetor or a carburetor out of adjustment, poor fuel and chilled cylinders.

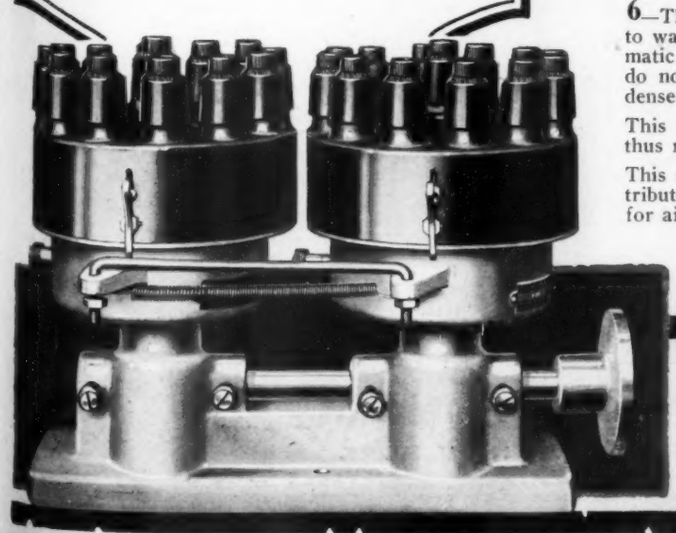
4—Perfect spark synchronism is secured in both the Single Spark and High Frequency systems by feeding the current to both distributors through *one* Contact Maker. There are two Contact Makers—one located in each distributor—but only one serves at a time. A selective switch makes either one available.

5—The combination of the three systems and the simplicity of the Philbrin Contact Maker render ignition failure practically impossible. This Contact Maker operates *practically without lag* and has ample capacity for any speed the engine can attain.

6—The Philbrin Armored Condenser is completely immune to water (even when submerged in sea water), moisture, climatic changes, altitude or other extraordinary conditions. We do not know of a single instance wherein a Philbrin Condenser, passed by us, has broken down.

This type of system for airplane use is made of aluminum, thus rendering the entire outfit extremely light.

This reproduction shows the Contact Maker and double Distributor of the Philbrin 12-cylinder, double ignition system for airplane motors.



PHILIPS-BRINTON COMPANY
525 South Broad Street
Kennett Square, Pa.

I Am Public Opinion

All men fear me!

I declare that Uncle Sam shall not go to his knees to beg you to buy his bonds. That is no position for a fighting man. But if you have the money to buy, and do not buy, I will make this No Man's Land for you!

I will judge you not by an allegiance expressed in mere words.

I will judge you not by your mad cheers as our boys march away to whatever fate may have in store for them.

I will judge you not by the warmth of the tears you shed over the lists of the dead and the injured that come to us from time to time.

I will judge you not by your uncovered head and solemn mien as our maimed in battle return to our shores for loving care.

But, as wise as I am just, I will judge you by the material aid you give to the fighting men who are facing death that you may live and move and have your being in a world made safe.

I warn you—don't talk patriotism over here, unless your money is talking victory Over There.

I am Public Opinion!

As I judge, all men stand or fall!

Buy U. S. Gov't Bonds Fourth Liberty Loan

Contributed through Division of Advertising

United States Gov't Comm. on Public Information

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1790 BROADWAY NEW YORK

OCTOBER 1, 1918

AVIATION
AND
AERONAUTICAL ENGINEERING

VOL. V. NO. 5

Member of the Audit Bureau of Circulations
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120 WEST 32D STREET, NEW YORK
WASHINGTON OFFICE, EVENING STAR BUILDING

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A Soldier Facing Death For You

Somewhere in France today, at this very minute, there is a soldier looking straight into the face of death.

He is doing this for *you*.

By night and day, in storm, in rain, in cold and gloom, facing a hundred deaths he never hesitates a minute but does his duty without a thought of hesitation and without a thought of reward.

What are you doing for him today?

When you think of that man don't you want to do something to prove that you appreciate what he is doing for you?

Of course you do. Then act on your desire and buy *Liberty Bonds* which will help to safeguard him and to bring him back home.

After *you* have bought all you can tell your friends to do the same.

BUY LIBERTY BONDS TODAY
ANY BANK WILL HELP YOU

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Special chrome alloy steels are made to the specifications of our engineers and personally overseen by our experts.

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When we know we have the best steel it is possible to produce — then only is it ready to to be made into

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BUSINESS MANAGER

Vol. V | October 1, 1918 | No. 5

Limit Performance of Airplanes*

With a Discussion of the Problem of Transatlantic Flight

By Prof. George de Bothezat

Aerodynamical Expert, National Advisory Committee for Aeronautics

Before taking up the question of the performance which may be expected from the airplane in the near future, it seems pertinent to examine in a general way the possibility of the airplane being replaced by aircraft founded on other principles of dynamic sustentation. Among such possibilities the ornithopter, or flapping-wing machine, and the helicopter, or direct-lift machine, present the greatest interest.

In the ornithopter the principal organ which produces lift and propulsion undergoes a reciprocating motion. This motion has a serious drawback in that it generally develops very high stresses in the materials of construction, thus causing their rapid deterioration and fatigue. This is why in all machines we seek to prevent, in the measure of possibility, the occurrence of reciprocating motion. From this viewpoint, then, the airplane has every advantage over the flapping-wing machine. Of course, should it be proven that the power absorbed by the ornithopter is sensibly inferior to that absorbed by the airplane, then—but only then—the study of ornithopters might present some interest; but we actually do not possess any precise indication on this question.

It is curious to note that, not only are we unable to measure the power spent by the bird in flight, but it is also extremely difficult to appreciate the power spent by the human being in moving itself. We generally have very confused ideas on the power developed by a living being; for instance, text books often state that the power developed by man is nearly equal to one-seventh of a horsepower. However, it is sufficient to quickly run up a staircase—in which case the amount of power developed can easily be measured—to realize that one manpower may occasionally equal two horsepower for 10 or 20 seconds.†

It is also quite possible that the power developed by birds in flight is not so small as might seem at first sight. The fact that, in comparison to their weight, birds generally take more food than other animals tends to indicate that they probably develop more energy for an equal weight.

Altogether, it is difficult to acknowledge at the present time the hypothetic superiority of the ornithopter over the airplane, so that one really fails to see why the flapping-wing machine should be expected to advantageously replace the airplane in the near future. Still, the study of the phenomena of flapping wings is of considerable scientific interest and will no doubt be better elucidated by recent progress made in the study of the phenomena of air resistance of aerofoils.

We know that, in general, the lift and drift of an aerofoil moving with a uniform translatory velocity are the result of a system of vortices in quincunx which appear in the wake of the aerofoil. In an ornithopter it would be sufficient that the flapping motion of wings produce an inversion in the senses of some of these vortices, so that, the lift being maintained, there would occur, instead of the drift, a propulsive thrust. Undoubtedly the study of the phenomena attending the motion of flapping wings will eventually lead to a clearer comprehension of many aspects of the delicate problem of fluid resistance.

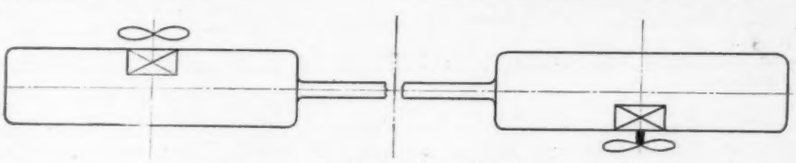


FIG. 1

Since the helicopter seems to many a particularly attractive proposition, I shall dwell somewhat at length on its comparison with the airplane.

Let us suppose that a clever inventor who is a convinced advocate of the helicopter sets out to build such a machine, and that he possesses really deep knowledge of the properties of blade screws—which is not generally the case for the inventors of helicopters. After he will have worked out the general scheme of his apparatus, which will necessarily have to be lifted by two blade screws revolving in inverse sense, he will proceed to lay out the design of the blade screws. Here the first requirement is to design screws endowed with as high an efficiency as possible, and in this endeavor the inventor should discover that the efficiency of lifting screws is generally somewhat lower than that of propulsive screws. He may find out afterwards that, for the purpose of getting high specific lift, that is, a large number of kilograms of lift per horsepower, it will be necessary that the blade screws have a very large diameter and revolve very slowly.

An engine of 10 hp. would thus give the following results:‡

Diameter	Rotational Speed	Specific Lift§
≅ 2 m.	≅ 600 r.p.m.	≅ 5 kg.
≅ 4 m.	≅ 240 r.p.m.	≅ 7 kg.
≅ 6 m.	≅ 120 r.p.m.	≅ 10 kg.
≅ 10 m.	≅ 50 r.p.m.	≅ 14 kg.

If this inventor were satisfied with a specific lift of 10 kg., then for engines of different power he would find the following:

Power	Rotational Speed	Diameter
1 hp.	360 r.p.m.	2 m.
5 hp.	180 r.p.m.	4.5 m.
10 hp.	120 r.p.m.	6 m.
50 hp.	30 r.p.m.	14 m.
100 hp.	6 r.p.m.	25 m.

It may be seen that the diameter of the screw increases rapidly with the power and that, in consequence, the realization of a helicopter would necessitate the construction of blade screws of very large diameter.

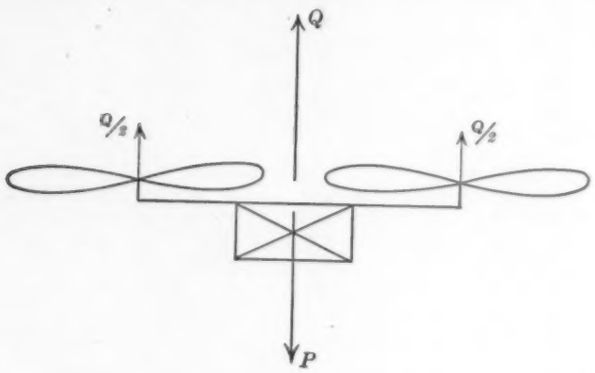
* Lecture delivered on invitation at the Massachusetts Institute of Technology.

† One horse easily pulls a carriage, but an automobile requires an engine developing some ten horsepower at least. This goes to show that on a bad road, when the horse makes an effort, the power it temporarily develops is equal to a good many mechanical horsepower.

‡ The writer has calculated and designed a family of lifting screws with an efficiency of 0.65, and the values thus obtained, while forming only a first approximation, give a correct idea on the order of the values of the quantities considered. It should be noted that it is difficult for lifting screws to exceed an efficiency of 75 per cent.

§ The writer calls specific lift of an helicopter the ratio of its lift to the power absorbed, that is, the lift per horsepower.

But we no sooner consider the problem of transmitting the work of the engine to the shaft of a screw of very large diameter than we realize that there is no advantage in transmitting the power directly to the shaft of the screw because this would develop large bending moments in the blades and require great structural strength for overcoming it—which requirement would obviously lead to great weight. One's thought is thus directed to the solution of fitting in the middle of each blade a small propeller driven by a special engine, as shown in Fig. 1, whereby the rotation of the screw may be effected under much more advantageous conditions. But in this case one might as well cut the big lifting screw in two, and thus obtain two airplanes.



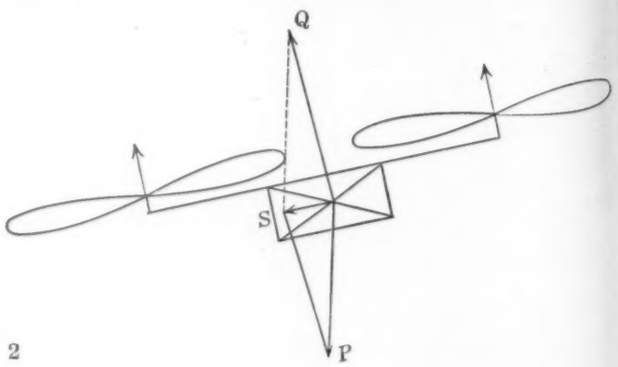


FIG. 2

We thus arrive at the rather unexpected result that on investigating the most favorable conditions for establishing a helicopter we are brought back to the airplane type of machine. Still another circumstance is unfavorable to the helicopter. Suppose we have an helicopter which is able to lift itself, then there still remains to be solved the question of its stability, because an helicopter fitted with nothing but two lifting screws has no inherent stability. If, for instance, an helicopter, as schematically represented in Fig. 2, should for any reason assume an inclination, then the thrust Q of the propeller, and the weight P of the machine will introduce a resultant force S which will cause the apparatus to assume a laterally directed descending motion. Now, there is no known reason why a restoring moment should occur to counteract this descending motion. We therefore see that for the practical realization of the helicopter some arrangement must be developed which will insure its stability.

The advocates of the helicopter always claim for their apparatus the great advantage of its being able to lift itself

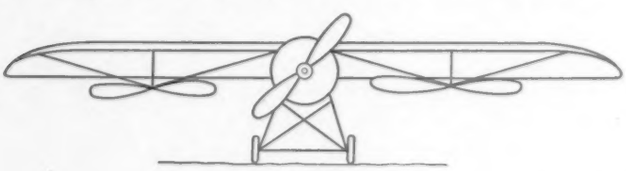


FIG. 3

vertically from the ground. In this matter they are likely to be greatly deceived. There already exists a type of aircraft which is capable of lifting itself exactly along the vertical, namely, the aerostat, or free balloon. However, it is but exceptionally that a balloon is seen ascending vertically because the slightest wind converts the vertical ascent into a curved trajectory.

An aircraft of any type may hover over its starting point only if it possesses a velocity superior to the velocity of the prevailing winds. This rule was well demonstrated by the first airships, whose self-velocity* was so low that they could not make any progress against winds of any but low velocity. Likewise, the airplane became independent of the wind and, consequently, really able to fly only when its self-velocity exceeded 100 km.p.h., which velocity the wind only seldom attains.

To hover with certainty over a given point aircraft other than airplanes must possess the latter's present self-velocity, a problem which is far from being solved in the helicopter. We thus see that the helicopter has no advantage over the airplane in the matter of hovering.

I have dwelt so much on the various drawbacks of the helicopter that I shall, in the end, say something in its favor. In certain cases the helicopter may find useful application. For instance, one might study the question of substituting for the observation balloon a captive helicopter; this should prove, if practicable, a valuable military instrument in that the helicopter would have much smaller dimensions than the balloon, and would, consequently, be much more difficult to detect. Military observation would thus be much safer and more efficacious, while, on the other hand, the necessity of producing or storing hydrogen for refilling purposes would be obviated.

Finally, it might not seem unreasonable to try to add later on a pair of lifting screws to the actual airplane; this could be effected by fitting a screw under each wing, a certain distance from the body, from which arrangement some advantages might be derived (Fig. 3).

In conclusion I do not think it possible to advantageously replace in the near future the airplane by a dynamic aircraft of another kind. This is why the examination of the question which is here termed the limit performance of airplanes presents real interest. In the discussion which follows I propose to examine in succession the question of the limit speed of the airplane, of the limit load it may carry, and of the limit distance it may fly without alighting.

The Limit Speed

When an airplane is flying horizontally at a uniform speed, the lift of its wings must necessarily be equal to its weight. We must consequently have

$$P = K\,A\,V^2\,i \qquad (1)$$

where K is the coefficient of air resistance, A the wing area, V the self-velocity, and i the absolute angle of incidence.

Attention should be paid to the fact that, for the angles of incidence currently used in airplanes, we always find ourselves within the linear variation of lift.

From formula (1) we obtain

$$V = \sqrt{\frac{P}{K\,A\,i}} = \sqrt{\frac{p}{K\,i}} \qquad (2)$$

in which p is the load per unit of wing area.

The limit value of velocity V therefore depends upon the largest load p which may be carried per unit of wing area, and upon the smallest angle of incidence i it is permissible to choose.

Let us first examine the question of the smallest angle of incidence. To avoid any misunderstanding I find it necessary to briefly deal with the conception that should be had of this angle. The incidence i is the element by which the orientation of the wings of an airplane is determined with the respect to the relative wind.

* The writer takes leave to introduce here the following terminology: *Self-velocity* is the velocity of aircraft relative to the air; *absolute velocity*, the velocity of aircraft relative to the ground (the earth being our absolute reference system in this case); and *wind velocity*, the velocity of the wind at the place the aircraft is flying. The absolute velocity is always the geometrical sum of self-velocity and wind velocity.

It is customary to choose, rather thoughtlessly, as a reference line of this angle what is called the chord of the aerofoil, or wing section. It is in the word chord that the misunderstanding of the definition resides. In geometry the chord is defined as a straight line connecting two points of a curve. But what is the chord of an area such as an aerofoil? Nobody knows it exactly and, still worse, it is impossible to establish such a definition.

Where an aerofoil is formed by two intersecting curves we instinctively take as chord the common chord of the curves which limit the considered section (Fig. 4, a). But for an aerofoil such as represented in (b), Fig. 4, two chords can in fact be drawn. We are still more perplexed when called to choose a chord in a case such as (c), Fig. 4, where any line drawn through the aerofoil may, for an equally good reason, be considered as the chord. It appears from the above examples that the chord, as used in its customary meaning, is nothing but an arbitararily chosen reference line.

Were we to deal only with aerofoils of a standard type the above outlined arbitrariness would not constitute a serious drawback, nor cause any difficulty of application. But the trouble starts when we want to compare the angles of incidence of aerofoils of different shapes. When, for instance, can it be truthfully said that the aerofoils *b* and *c* have the same angle of incidence?

Where we deal with a flat plate the definition of the incidence does not present any difficulty, for it is obviously the

FIG. 4

angle between the relative velocity and the plate itself (Fig. 5). But what is the principal aerodynamical characteristic of the direction of a flat plate? Nothing but the direction at which the lift of the plate is equal to zero. When the wind blows along the plate the whole air resistance is reduced to drift, there being no lift at all. It is consequently from the direction of zero lift that the incidence of a flat plate is measured, which direction is in that case the reference line.

Many years ago Paul Painlevé suggested that the direction of zero lift be adopted as the standard reference line for all types of aerofoils, this direction being in every case perfectly well determinable. It is this definition that I shall adopt for the standard reference line of aerofoils. To find this direction we only need to determine for which orientation of the aerofoil, in a uniform flow, we get zero lift. At this moment the entire resistance of the wing is reduced to drift. We shall call the line of zero lift, or in short the *zero line*, the straight line which contains the drift when the lift is of zero value (Fig. 6). The absolute incidence i will then be the angle between the zero line and the relative wind. An angle of incidence of five degrees thus means that a decrease of five degrees in the incidence will bring about zero lift. In formula (1) the absolute angle of incidence corresponds to this definition.*

A fundamental factor incidentally puts a limit to the smallest value of the incidence which may be adopted for practical purposes, and this remark necessitates a short digression from the domain of the mechanics of the airplane.

Let us draw through the center of mass of an airplane in flight for its rectilinear and uniform steady motions a set of lines which are successively parallel to the zero line of the aerofoil, to the thrust of the propeller, to the self-velocity V, to the weight of airplane P, to the drift R_x (which has the inverse sense of its velocity V) and to its lift R_y (Fig. 7). Let further i_o be the angle of incidence in normal horizontal flight, i the angle of incidence of the actual steady motion, and γ the inclination of velocity V on the horizontal, which inclination will be counted as positive when the airplane is climbing. As soon as the airplane has reached a state of steady motion the forces acting on the machine must be in

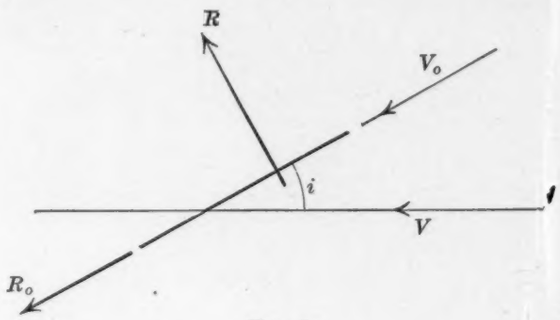


FIG. 5

mutual equilibrium. By projecting these forces on the velocity and on the normal to the velocity we have

$$R_x = Q - P \sin \gamma \quad \ldots\ldots\ldots\ldots\ldots (3)$$

and

$$R_y = P \cos \gamma \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

which formulas constitute the fundamental relations for all kinds of rectilinear motions of an airplane. Dividing formula (3) by formula (4), and considering in the first approximation $\cos \gamma = 1$, and $\sin \gamma = \gamma$, then

$$\frac{R_x}{R_y} = \frac{Q}{P} - \gamma \quad \ldots\ldots\ldots\ldots\ldots (5)$$

from which

$$\frac{Q}{P} - \frac{R_x}{R_y} = \gamma \quad \ldots\ldots\ldots\ldots\ldots (6)$$

The drift-lift curve R_x/R_y in functions of the angle of incidence i has the general form represented in Fig. 8. On the other hand it may be easily seen that the thrust-weight ratio Q/P may also be considered as a function of the angle of incidence. In fact the weight of the airplane is a constant—

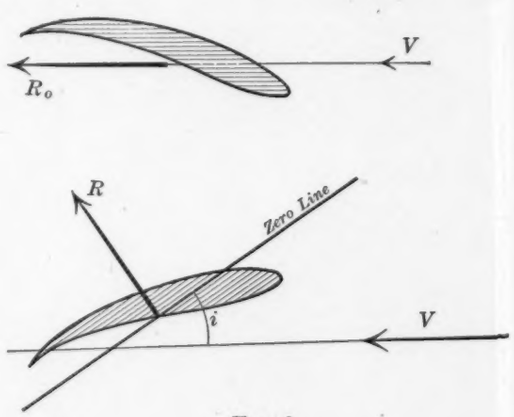


FIG. 6

at least for a certain time—and the thrust of its engine-propeller group is only a function of the translatory velocity and of the gas admitted into the engine.†

* The advocates of the old system object to the new definition that experimentally it is difficult to measure the angle of incidence from the zero line. That is purely a matter of experimental convenience and does not concern this discussion. It is obvious that for practical purposes it is desirable to choose the most convenient reference line; but when it comes to the representation of experimental results the incidence should always be given in absolute values, because only thus is sensible comparison possible.

† This fundamental property of the engine-propeller group may be promptly grasped from the following example: Suppose we place an internal combustion engine provided with a propeller on a railroad car. If the car is motionless and the engine is set running with a given gas admittance, the propeller will make a given number of revolutions, and thus furnish a given thrust which will be invariable as long as the gas admittance remains uniform and the car stationary. But now, while maintaining gas admittance uniform, let the car assume a given velocity. For each value of the car's velocity the engine will give a different number of revolutions, but as long as the velocity of the car is maintained at a uniform value the propeller will give a uniform number of revolutions, and therefore furnish a constant thrust. We thus find that in the engine-propeller group the thrust of the propeller is only a function of the translatory velocity of said group, and the gas admittance; and that as long as the gas admittance remains uniform the thrust will be a function of the velocity only.

But the velocity of an airplane is in the first approximation only a function of its incidence, so long as the load remains uniform, so that for a uniform gas admittance the ratio Q/P is a function of the incidence only. The thrust-weight curves in functions of the angle of incidence are represented in Fig. 8.*

The point where these two curves intersect gives us the angle of incidence for normal horizontal steady motion, as may easily be seen from formula (6). Any change from this incidence will cause the airplane to climb, or descend, at an angle the value of which is directly given by the difference

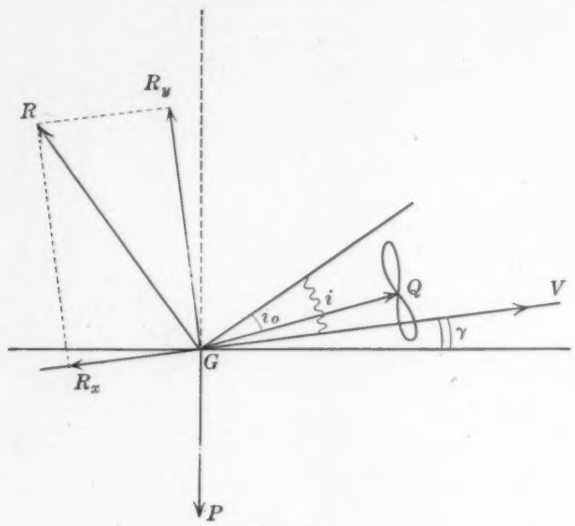


FIG. 7

of the ordinates of the thrust-weight and drift-lift curves, the latter corresponding to the given angle of incidence (Fig. 8).

It follows from the shape of the thrust-weight and drift-lift curves that if the angle of incidence is too small in horizontal steady motion then the slightest decrease in incidence will produce very large negative values of γ which means that such an airplane will nose-dive upon the slightest decrease in incidence. In other words, this kind of instability should directly be attributed to excess of sensitiveness to descent.

Airplanes in which the mistake is committed of adopting too small an angle of incidence for horizontal flight are all more or less characterized by a tendency to nose-dive when flying with small loads, and furnish satisfactory performance only with heavy loads, because an increase in load obviously requires an increase in the angle of incidence, thus removing the above indicated objections. It should therefore be noted that in an airplane excessive sensitiveness to descent is always caused by too small an angle of incidence.

Certain writers have stated that too small an angle of incidence is dangerous because a slight inclination of the machine may throw the wind on the back of the wings and so cause it to nose-dive. Such a conception is very naïve indeed. It often happens that, during their evolutions, airplanes get the wind on the back of the wings—that is why the latter must also be able to withstand downloads—and are nevertheless able to climb during that down-wind. This is what generally occurs when an airplane is made to climb immediately upon coming out of a dive. An inherently stable machine always tends to recover the normal angle of incidence, should the latter be suddenly displaced by negative lift, which in this type of airplane is only an intantaneous phenomenon. The inferior limit of the incidence is consequently not determined by negative lift, which is a general phenomenon, but by the above mentioned factor of excessive sensitiveness to descent.

The inferior limit which may be adopted for the angle of incidence depends upon the type of aerofoil and the drift of the machine taken as a whole. In the most favorable case it seems difficult to adopt an absolute incidence of less than *three degrees*, and, without any doubt, *two degrees* of absolute incidence should be considered as the extreme limit admissible.

Now let us examine the limit value that may be adopted for the load per unit of wing area. On one hand we are limited in realizing a high loading by the necessary safety factor that must be given the wings; but more than this consideration it will be the landing speed which will prevent us from exceeding certain values of p. If K'_y be the greatest value of the lift coefficient K_y of the airplane wing in question, then the smallest value V_m of the velocity which the machine may assume in steady motion, which is its landing speed, will be furnished by the relation

$$P = K'_y A V_m^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$V_m = \sqrt{\frac{P}{K'_y A}} = \sqrt{\frac{p}{K'_y}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The velocity V_m appears, therefore, to be proportional to the square root of the load p per unit of wing area. In actual airplanes a wing loading of 60 kg. per sq. m. has only very seldom been exceeded† on account of the low speed required for landing. For this reason I believe that we may adopt as the extreme limit of the load p a value of 100 kg. per sq. m., which it will likely prove difficult to exceed before long.

If we introduce these extreme values for p and i in the formula (2), and note that, for nearly all of the existing aerofoils, the coefficient K has a value approximating 1/200, then

$$V = \sqrt{\frac{p}{Ki}} = \sqrt{\frac{100}{1/200 \times 2}} =$$

$$\sqrt{10{,}000} = 100 \text{ m.sec.} = 360 \text{ km.h.} \quad \ldots\ldots\ldots\ldots (9)$$

We thus see that the highest speed that may be obtained with an airplane is 360 km. per hour. It should, however, be noted that this value really represents an extreme limit, and I do not believe that, in view of what has been said above, we shall in the immediate future see airplanes fly at a speed exceeding 300 km. p. h., though at the present time I do not know of any airplane that has ever attained a speed in excess of 250 km. p. h. This speed limit may cause a profound disappointment to those who have hopes that a flight speed of 500 km. p. h. is perfectly feasible. It should, however, be realized that a wing loading of 100 kg. per sq. m. would undoubtedly require the use of artifices, such as a device insuring a variation of the wing area at the moment of landing, or an increase of the coefficient K'_y through a variation of the wing curvature. The latter arrangement would seem more practical than a variable wing area, which would entail very great constructional difficulties.

The Limit Distance

The question of maximum flight endurance, that is, the greatest distance an airplane can fly without re-fuelling, constitutes one of the most important problems of aviation. As there can be no doubt but that the airplane will in the near future become one of the most rapid and convenient means of transportation, it is of the highest interest to appreciate, so to say, its range.

This question is of timely interest particularly now, when the gigantic problem of crossing the Atlantic by way of the air is awaiting its solution. More than one constructor, fully conversant with the importance of this problem and the necessity of its being promptly solved, is animated by the desire to bring about its realization. But desire, however great, is not sufficient to secure realization. Indeed, this problem presents some very great difficulties which I propose to duly discuss here, and, at the same time, indicate a rational method for its solution.

To begin with, the transatlantic flight should not be considered as a sporting performance. While it would, of course, be highly gratifying to see the accomplishment of such a venture, still an isolated success, unlikely to be duplicated, would needs remain meaningless for practical purposes. What we really need is the technical solution of this problem, whereby an air route linking America with Europe would become a systematically realizable possibility. It is from this, purely technical, point of view that I shall examine the question.

* Lack of space compels me to deal very briefly with this subject, which belongs to the general theory of the engine-propeller group and of the steady motion of airplanes, but I propose to treat this question in due time more in detail.

† The highest wing loading of which one has record was incorporated in the Deperdussin single-seater monoplane which won the 1913 Gordon-Bennet race. This machine actually carried 62.5 kg. per sq. m. of wing area, but its landing speed was so high as to require an exceptionally large and smooth-surfaced landing ground.

The technical problem to be solved demands essentially the determining of the conditions which an airplane must fullfil to be capable of making a continuous flight from America to Europe. The *variante* which allows for several intermediate stops for the purpose of taking on fuel from supply ships must be rejected as involving too many difficulties and dangers entirely foreign to the problem itself. The manifold complications of this scheme are so manifest that I shall not stop to examine them.

Two principal routes appear available for the crossing of the Atlantic by airplane. The first, from Newfoundland to Ireland, involves a continuous flight of approximately 3,000 km., while the second route, from Newfoundland to Portugal by way of the Azores, comprises two legs of 1,900 and 1,400 km., respectively. It is obvious that the first of these routes, being the most direct, is the more desirable of the two.

For the success of such an enterprise it seems necessary that there should be added to the actual flight distances a safety margin of 50 per cent., to take care of deviation from the true course and for contrary winds. This would mean that, in the first case the transatlantic airplane must be able to fly without re-fuelling a distance of about 4,500 km., and, in the second case, a distance of nearly 3,000 km. This majoration of distances, while far from being exaggerated, should be considered as fully sufficient to insure the success of the crossing under normal weather conditions.

Let us now examine in what measure we may hope, given the conceptions which form the basis of modern airplane construction, to build an airplane capable of covering such distances in a continuous flight.

If L_m is the power of the engines fitted to the airplane, and ϱ the efficiency of the propeller, or propellers, then the power the machine develops in horizontal flight will be ϱL_m, which is equal to the resultant thrust Q of the propellers multiplied by the self-velocity V. We consequently have

$$\varrho L_m = QV \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

If q expresses the ratio of thrust Q to the total weight P of the airplane, fully loaded, that is

$$q = \frac{Q}{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

then for horizontal flight the latter formula is evidently equal to

$$q = \frac{Q}{P} = \frac{\text{Drag } R_x}{\text{Lift } R_y} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

By substituting in formula (10) for Q the value given in formula (11) we find that

$$75\,\varrho L_m = qPV \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

This is the fundamental formula characteristic of the horizontal flight of airplanes, L_m being expressed in horsepower, P in kilograms, and V in meter-per-seconds, while ϱ and q are independent of the system of units chosen. The formula (13) may also be written as follows:

$$\frac{75\varrho}{q} = \frac{P}{L_m} V \quad \ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Now let f express the ratio of the useful load of an airplane to its total weight P, then the useful load will be equal to fP.

Where we have to deal with airplanes of very large capacity, the useful load may be considered as being virtually equal to the weight of the fuel which the airplane can carry, because in this case the weight of crew and instruments is but a comparatively small portion of the total load.

If c indicates the gasoline consumption per horsepower-hour, then the gasoline consumption per hour of the entire power plant will be cL_m and the greatest number of flight hours h the airplane could furnish will be

$$h = \frac{fP}{cL_m} \quad \ldots\ldots\ldots\ldots\ldots\ldots (15)$$

If we now indicate by L the greatest distance (in km.) which the airplane can fly until exhaustion of its fuel supply, then

$$L = 3.6Vh^* \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

If in the latter formula we substitute for h the value given in formula (15), and express in the latter P/L_m in terms of the formula (14), we finally get

$$L = 75 \times 3.6\frac{\varrho f}{qc} = 270\frac{\varrho f}{qc} \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

We thus have come to see that in the ultimate analysis the radius of action of an airplane depends upon the following fundamental factors:

The efficiency of the propellers ϱ;
The relative resistance q (which is equal to R_x/R_y);
The fuel consumption per horsepower-hour c; and
The ratio of useful load to total weight f.

Let us now in a general way determine the values which these factors assume in the modern airplane, and find out in what—if any—measure their influence on flight qualities may be improved by an increase in the size of an airplane.

It is at first sight obvious that the coefficients ϱ and c are independent of the size of the airplane. While the efficiency ϱ of modern air propellers averages 75 per cent, the writer is of the opinion that, by applying certain methods evolved by him for this purpose, propellers having an efficiency of not less than 85 per cent may be designed without any difficulty. As to the factor c, this varies for the best existing engines between 0.25 and 0.30 kg. per horsepower. Consequently, in the discussion of this problem, the values of ϱ and c must be considered as fixed by the perfection attained in the design of propellers and engines.

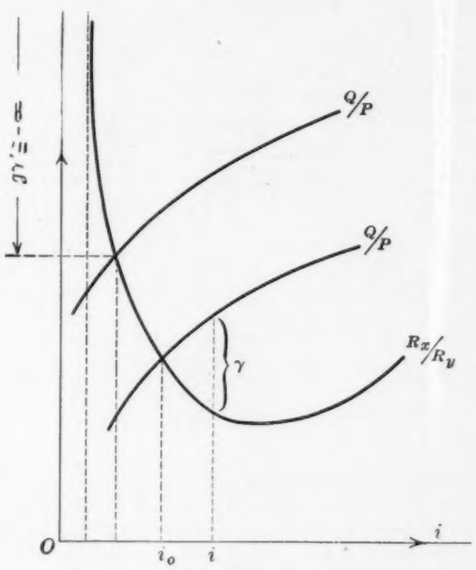


FIG. 8

The coefficient q characterizes the ratio of the drag of an airplane (wing and parasite resistance) to its lift for the angle of incidence corresponding to normal horizontal steady flight.

It is well known that the ratio R_x/R_y goes through a minimum q_m for a certain value i_m of the angle of incidence. But the angle of incidence corresponding to horizontal steady motion must necessarily be smaller than i_m because the steady motion corresponding to the latter angle is characterized by a series of properties which make it unavailable for practical purposes. For instance, if flying horizontally with the angle of incidence i_m, the slightest wind directed downward will cause the airplane to descend; the machine is then unable to climb, or to withstand any overload, such as a light rain-fall, without descending.† This is why the value to be adopted for q must necessarily be greater than q_m.

The ratio $(q - q_m)/q_m$ is even a more important characteristic of airplanes, for their flight qualities are directly dependent upon its magnitude.

* The factor 3.6 must here be introduced owing to the fact that V is expressed in meter-per-seconds, and L in kilometers.

† The writer is unvoluntarily very short on this subject, a detailed discussion of which would carry us far beyond the scope of this article.

While writing these lines, the writer has before him a table giving the complete characteristics of nearly all existing airplanes,* from which it appears that for modern flying machines the value of q varies between 0.17 and 0.28. As a rule, high-speed, and high-climbing machines have large values of q; on the other hand, the smaller the drag of an airplane, the more is q reduced.

A geometric increase in the size of a machine, creating a model in all respects similar to its prototype, causes q to decrease but slightly. The reason for this may be found in that for a reduced model of an airplane the drag comparatively increases with respect to the full-size model. Inversely, when we increase a machine in size we may expect that its drag will somewhat decrease.

However one should not attach undue importance to this phenomen, for it only shows that for geometrically similar airplanes q has a tendency to *slightly* decrease with an increase in size of the machine.

Let us now examine the value we may assume for the coefficient f. The total weight of an airplane ready for flight is composed of the following items:

The weight of the airplane, less its power plant, P_a;

The weight of the power plant, P_m; and

The useful load, P_u, which is equal to $f\,P$.

We consequently have

$$P = P_a + P_m + P_u$$

If we consider a series of geometrically similar airplanes having all the same load per unit of wing area, it will readily be seen that the total weight of the airplane P will be proportional to the wing area A, and that the weight of the engineless airplane P_a will be proportional to the cube of its linear dimensions, that is to say, proportional to $A^{\frac{3}{2}}$, the safety factor uniformly applied to the airplane series considered.†

We may consequently write

$$P_a = rP^{3/2}$$

where r is the coefficient characteristic of a given type of airplane.

The weight P_m depends upon the power L_m of the engines, and may be written

$$P_m = mL_m$$

where m is the weight of the engines per horsepower, which depends upon the type of engine chosen. For the best water-cooled engine in existence m averages 2 kg. per hp.

We consequently have

$$P = rP^{3/2} + mL_m + f\,P \quad \ldots\ldots\ldots\ldots (18)$$

or

$$f = 1 - r\sqrt{P} - m\frac{L_m}{P} \quad \ldots\ldots\ldots\ldots (19)$$

By substituting in the latter formula for L_m/P the value given by formula (14) we get

$$f = 1 - r\sqrt{P} - m\frac{qV}{75\rho} \quad \ldots\ldots\ldots\ldots (20)$$

This formula enables us to draw the following important conclusions:

I. The coefficient f decreases with the speed of the airplane. As is well known, high-speed machines carry a lesser useful load than low-speed airplanes.

II. The coefficient f decreases with the total load of the airplane. If we should want to maintain f at a constant value while increasing the value of P, this could be done either by reducing the coefficients m and q, or else, by increasing the efficiency ρ, always assuming that a decrease of speed is not desirable.

The latter conclusion enables us to judiciously gage the enormous difficulties attending the problem of transatlantic flight. It must be quite obvious that an increase in the size of a given airplane does not lead us any nearer to the right solution, because in this case the values of ρ, q, and c remain uniform, while f decreases.

Regarding the coefficient r I should like to say, with reference to what has previously been mentioned, that for airplanes having a large carrying capacity and medium speed the value of r is of the order of

$$r = 0.005‡$$

From the foregoing it is easy to see that we may count on obtaining for f a value of 0.5 while remaining within the possibilities of present aerodynamics.§

Having thus fixed the values of the coefficients ρ, c, q, and f we may now determine the limit distance an airplane can fly without re-fuelling.

I. Taking good average values, we may assume $\rho = 0.75$; $c = 0.25$; $q = 0.2$; $f = 0.5$ from which it follows that

$$L = 270\frac{0.75 \times 0.5}{0.2 \times 0.25} = 2000 \text{ km.}$$

which corresponds to the greatest distance ever having been flown by an airplane. It may thus be seen that considerable improvements must be achieved in airplane construction if we are to produce a machine capable of flying the distances necessary for crossing the Atlantic.

If we realized

$$\rho = 0.85;\ c = 0.25;\ q = 0.15;\ f = 0.5$$

then we would get

$$L = 270\frac{0.85 \times 0.5}{0.15 \times 0.25} = 3000 \text{ km.}$$

which limit distance would be sufficient for crossing the Atlantic by way of the Azores with the 50 per cent safety margin previously dwelt upon.

However, for a crossing via the direct route it would be necessary to realize the following values:

$$\rho = 0.85;\ c = 0.25;\ q = 0.1;\ f = 0.5$$

which would give

$$L = 270\frac{0.85 \times 0.5}{0.1 \times 0.25} = 4500 \text{ km.}$$

and suffice for a continuous flight from Newfoundland to Ireland.

It follows from the foregoing that an increase in propeller efficiency, and a decrease in the drag of airplanes are the most important factors affecting the success of the transatlantic flight.

But how are we to obtain such improvements? I shall try to outline here a fundamental conception affecting the whole problem. Since a mere increase in the size of an airplane is unable to give us the necessary increase of general efficiency, let us conceive an airplane built on the following principles:

(1) The possibility of effecting a geometric increase in the size of the machine—a thing that is not generally possible to achieve with every type of machine—and

(2) The possibility of increasing the airplane in size without increasing the number of its propellers, instead of which there would be a single propeller actuated by a group of engines connected to the propeller shaft. I should like to men-

---

* Owing to the war it is unfortunately not permissible to publish this interesting table.

† This statement may be justified by the following example:

Suppose we have to verify the resistance of two struts fulfilling the same function in two geometrically similar airplanes which carry the same load per unit of wing area, but one of which is n times larger than the other. As is well known, the resistance of struts is verified by Euler's formula

$$P = k_1\pi^2\frac{EI}{l^2}$$

where k_1 is the safety factor, E is the modulus of elasticity, I is the moment of inertia of the strut at the cross-section, and l is the length of the strut.

For the airplane n times larger the load will increase n^3 times, the length of the strut n times, and the moment of inertia of the strut at the cross-section n^4 times. In the case of the larger airplane we will therefore have

$$n^3P = k_2\pi^2\frac{En^4I}{n^2l^2}$$

which shows that k_1 is equal to k_2; in other words, as has been said before, the same safety factor will apply to both machines. Strength calculations for other parts of the airplane lead us to nearly the same conclusions.

‡ This may be justified as follows:

Suppose we have

$$P = 2000 \text{ kg.}$$
$$P_a = 0.25\,P$$

As already shown,

$$P_a = rP^{3/2}$$

So that we have

$$r = \frac{0.25}{\sqrt{P}} = 0.0055$$

§ For instance, if we complete the foregoing example by adopting the values $m = 2$; $q = 0.2$; $\rho = 0.75$, and $V = 40$ m.p.sec., we find from formula (20)

$$f = 1 - 0.0055\sqrt{P}\frac{2 \times 0.2 \times 40}{75 \times 0.75} \cong 0.47$$

tion here that the construction of very powerful airscrews endowed with high efficiency may already be considered as fully realizable.*

It may readily be seen that an increase in the size of such an airplane would produce the following results:

Having but one airscrew, actuated by a group of engines, the drift of the body will nearly remain of the same magnitude with an increase of the airplane's size, while for the large machine q will comparatively decrease with respect to the small machine. Furthermore, the coefficient r in the formula

$$P_a = rP^{\frac{2}{3}}$$

will also decrease with an increase of the airplane's size because the body will thereby become more and more compact.

If we adopt this fundamental conception of the *single-screw multi-engine airplane*, the solution of the transatlantic flight becomes to my mind a certainty, for the considerable advantages accruing from an increase in size of such a machine are likely to give a performance which will suffice for a non-stop flight from Newfoundland to Ireland.

The use of a single airscrew actuated by several engines, which would have to be fitted with suitable clutches permitting simultaneous or separate connection with the propeller shaft, would furthermore have the following advantages:

Suppose we have a group of N engines. From formula (13) we find that when the engines have consumed in flight an amount of gasoline equal in weight to P/N, we may then disconnect one engine because the power required for flight would by then be reduced to

$$\frac{N-1}{N} L_m$$

always assuming that the machine flies at the same speed and angle of incidence, that is, V and q remain constant (which values are merely a function of the angle of incidence), and the propeller maintains its efficiency ρ.

The latter requirement would necessitate having a propeller capable of absorbing decreased power at constant speed of rotation, and of yet maintaining its efficiency. The writer sees no real difficulty in the realization of such a propeller.

After the remaining engines will have consumed another portion of the fuel supply equal to P/N, a second engine may be disconnected, and so forth.

Let us now calculate the saving of fuel which may be attained in this way. It is obvious that the first engine could be disconnected after a number of flight hours equal to

$$h_1 = \frac{P}{NcL_m}$$

while the second engine may be stopped after a number of hours equal to 2 h_1, and so forth. The number of disconnected engines would at the end of the voyage be

$$\frac{fP}{P/N} - 1 = fN - 1$$

and the total gasoline consumption would under these circumstances amount to

$$\frac{cL_m}{N}\Big[Nh_1 + (N-1)h_1 + (N-2)h_1 + \dots \Big\{N - (fN-1)\Big\}h_1\Big]$$

or

$$\frac{cL_m h_1}{N} \times \frac{2N-(fN-1)}{2} \times fN$$

or, finally, by substituting the value of h_1

$$fP \times \frac{2N - fN + 1}{2N}$$

The ratio of the latter value to fP is consequently equal to

$$\frac{2N - fN + 1}{2N}$$

To illustrate the meaning of this formula, let $N = 10$, and $f = 0.5$, then

$$\frac{2N - fN + 1}{2N} = 0.8$$

which shows a 20 per cent saving in fuel consumption.

This method of successively disconnecting the engines has still another important advantage. After h_1 hours of flying we will have one engine in reserve, after $2h_1$ hours, two engines, and so forth; this will naturally enable us to substitute one of the reserve engines should one of the running engines show signs of fatigue. In fact, all the engines of the group may in turn be given a rest by substituting single units to one another, a feature which would be of very great importance for the transatlantic flight, where success demands prolonged running at full engine speed.

From the foregoing discussion the following conclusions may be drawn:

I. The maximum distance which an airplane may, in the near future, cover without re-fuelling may be estimated at 4,500 km. This is fully sufficient for crossing the Atlantic from Newfoundland to Ireland.

II. The rational solution of the transatlantic flight is furnished by the single-screw multi-engine airplane, which has over all other existing types the great advantage of being characterized by a decrease in drag and specific weight with an increase in size. With such an airplane the Atlantic could easily be crossed inside of 30 hours.

III. The development of a propeller endowed with high efficiency and means for absorbing variable power constitutes an additional important factor in the problem.

I finally want to point out that a machine built on these principles for the transatlantic flight would by no means prove useless for other purposes. Quite on the contrary, such an airplane, constituting one of the most powerful types ever built, would prove particularly desirable for military purposes, because a considerable portion of its useful load might be utilized for carrying armament instead of fuel. On the other hand, the variable power embodied in the single-screw, multi-engine airplane might open various important military possibilities which I prefer not to discuss at the present moment. Nor shall I undertake here to deal with the determining of the most desirable power and speed the transatlantic airplane should embody, for these questions pertain to the domain of actual design of the machine rather than to the general discussion of the transatlanic flight problem.

The Limit Load

It is obvious from the foregoing discussion that the useful load P_u has no limit, and increases with the total weight P. In fact, it may readily be seen from formula (13) that if we assume the factors ρ, q, and V to be constant, then the total weight P increases with the power.

On the other hand, from formula (20) we have

$$P_u = P - rP^{\frac{2}{3}} - m\frac{qV}{75\rho} P$$

or

$$P_u = P\left(1 - \frac{mqV}{75\rho}\right) - rP^{\frac{2}{3}}$$

and assuming m, q, ρ, and V to be nearly constant, we find that the useful load P_u is a function of the total weight P, as expressed by the formula:

$$P_u = aP - rP^{\frac{2}{3}}$$

which admits a minimum for only a very small value of P, a value that is actually devoid of practical meaning. Afterwards P_u becomes an increasing function of P. We have

$$\frac{\partial P_u}{\partial P} = a - \frac{3}{2} rP^{\frac{1}{3}} = 0$$

which gives

$$P = \frac{4a^3}{9r^2}$$

and we have

$$\frac{\partial P_u}{\partial P} = +\frac{3}{2} \times \frac{1}{2} \sqrt{\frac{r}{P}}$$

which quantity is positive for P equal to $\frac{4a^3}{9r^2}$ It follows that P_u is practically an increasing function of P. In consequence, the useful load P_u of an airplane always increases with its power. We should not, therefore be astonished to see in the near future airplanes carying enormous loads, though the latter increases at a somewhat lesser rate than in proportion to the power of the engines.†

* The writer, for instance, is prepared to design propellers up to 2000 hp., with an efficiency of not less than 85 per cent. The diameter of such propellers need not exceed 4 m.

† The writer wishes to express his thanks to Mr. L. d'Orcy, associate editor of AVIATION, for the care he has taken in editing this article.

Some New Enemy Airplanes

The Zeppelin Giant Airplane

For the past year or so numerous reports have been forthcoming from neutral sources to the effect that the Germans were experimenting with an airplane of gigantic proportions, which was said to be fitted with four, and even six, engines. Last spring six of these machines undertook a raiding expedition against the English coast, in the course of which two at least were brought down in the sea, but as they could not be salvaged no precise information was available as to their characteristics.

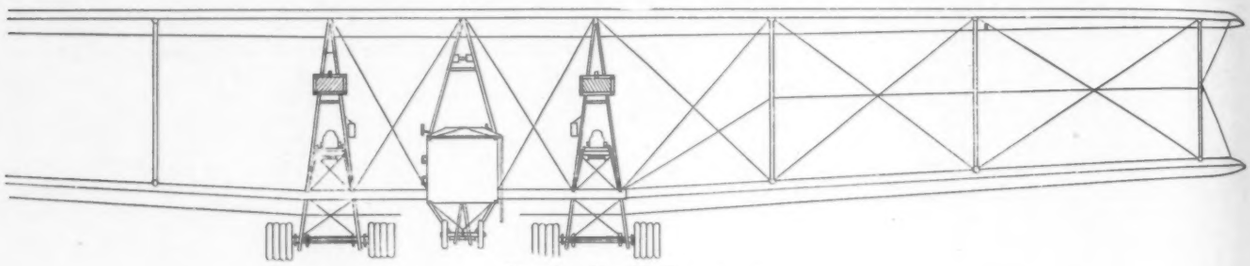


FIG. 1. FRONT ELEVATION

On June 4, 1918, however, a German airplane was captured by the French in the region of Soissons, which was of so unusual size—it carried a crew of nine—that it received the honors of the French daily *communiqué*. Upon examination the machine proved to be badly damaged, having first been burnt by its crew, then pillaged by interested spectators, so that it was difficult to obtain a correct idea of its features and many fanciful reports were published in consequence by the alleged aeronautic experts of the daily press. Fortunately M. Jean Lagorgette, technical editor of *L'Aérophile*—to whose perseverant investigations and clever deductive work the Allied world owes nearly all of its knowledge of Germany's war-born airplanes—has been able to reconstruct from the wreckage the machine as it appeared when intact. The following description, which has appeared under M. Lagorgette's pen in *The Aeroplane*, gives the results of this careful reconstruction

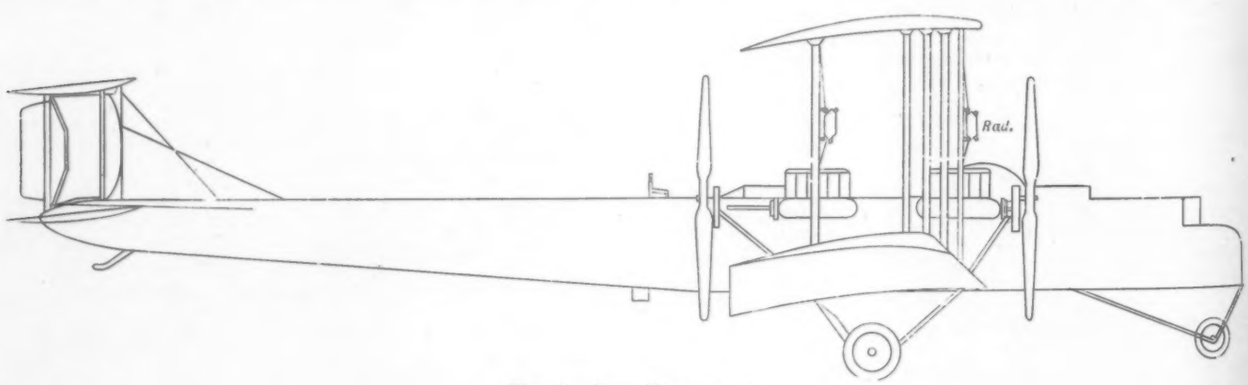


FIG. 2. SIDE ELEVATION

work, and is vouched by him to be—save perhaps for minor details—rigorously exact.

First of all, there is no doubt that this *Riesenflugzeug*—as the Germans call their giant airplanes—is a product of the Zeppelin Co., and constitutes apparently the latter's debut in the field of heavier-than-air machines. Besides the fact that the initials Z and LZ are painted or punched onto various pieces, there are several dispositions, such as a liberal use of aluminum-alloys in the construction of fittings, ribs, the girder-work of the tail planes, certain types of cable attachments, not to speak of the use of Maybach engines, and, finally, the gigantic proportions of the machine, all of which clearly indicate the Zeppelin firm as its builders. On the other hand, a doubt still exists as to whether the machine was built under Zeppelin license by the Albatros Works—whose initials also occur on the machine—or whether the converse was the case, though M. Lagorgette inclines towards the former conclusion.

However this may be, the fact remains that the Zeppelin Co. was to a large extent concerned in the realization of this machine, which disposes of the early reports that it had been built by the "Lizenz" firm—a deduction drawn from a wrong interpretation of a German inscription, which simply meant that the airplane in question had been built "under license."

It seems probable that the first machine of this model was tested in the early part of 1917 at Friedrichshafen; the captured airplane under review bore the reception date August 11, 1917, but it is possible that it was modified while in service, particularly its undercarriage, which bore the inscription *reinforced* in German.

Taken as a whole, the Zeppelin biplane cannot be said to revolutionize present-day airplane design, for it has hardly anything peculiar to itself except its enormous size. In fact, it may be considered as an enlarged and duly reinforced model of the well known enemy twin-engined bombers, except that the Zeppelin carries two engines, placed end to end on the same bearers, on either side of the body, so that there are two tractor, and two pusher screws. This disposition of engines was tried in France in 1916, and more recently in England too, but has invariably given unsatisfactory results in flight, because the pusher screws would naturally work in the wake of the tractors, that is, in disturbed air, and so give a poor performance.

But even in the matter of size the Zeppelin biplane does not constitute any pioneer achievement, for as far back as 1916 Voisin built a four-engined quadruplane, while Curtiss produced somewhat later a four-engined triplane flying boat, both of which had a maximum span of about 40 m., and various multi-engined biplanes and triplanes were created by Sikorski, Caproni, Bréguet, and Handley Page, to mention only the most notable manufacturers of dreadnought-airplanes.

This preamble having sufficiently cleared up the hidden and

visible influences which have presided over the conception of Germany's *Riesenflugzeug*, one may now proceed to describe the machine in detail.

The two planes are arrow-shaped only at the leading edge, while the trailing edge is in a straight line.

Incidence and Wing Section.—The incidence of the wings from the center line of the machine to the engine cabanes is determined by the two following points. The lower longerons of the body being horizontal in front, the lower side of the front spar of the lower wing rests directly on their upper surface, while the upper side of the rear spar only comes flush with the upper surface of the body longeron. This is to say, the angle of the under surface of the wings between the spars is fixed by the depth of the rear spar—that is to say, about 160 mm.

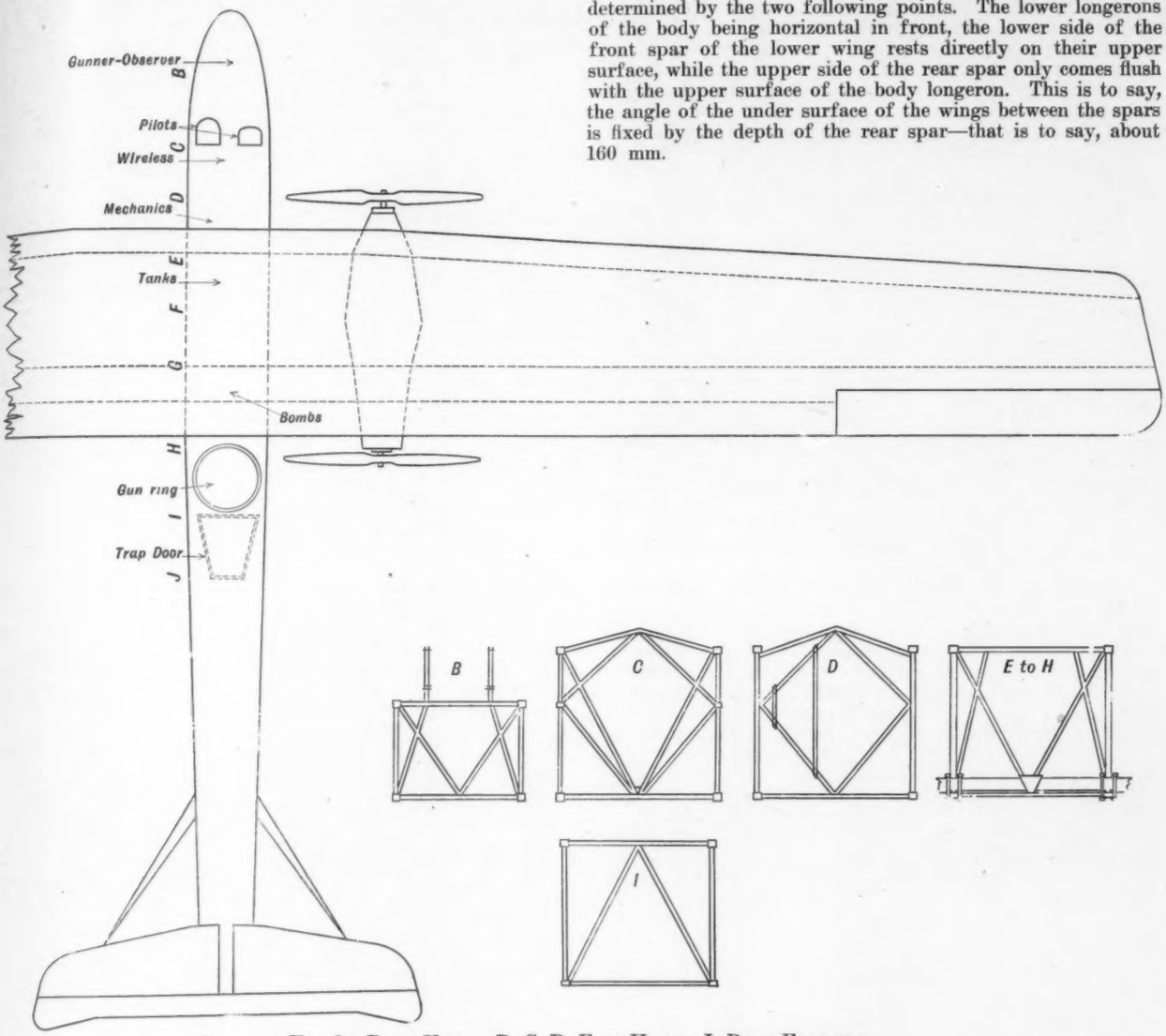


FIG. 3. PLAN VIEW. B, C, D, E TO H, AND I, BODY FORMERS

The Giant Airplane Described

The general dimensions of the Zeppelin biplane are as follows:

Span, upper and lower wings	41.00 m.
Overall length	22.00 m.
Overall height	6.40 m.
Gap, at center section	4.40 m.
Chord, at center section	4.50 m.
Gap, at outer interplane struts	3.62 m.
Chord, at wing tips	3.50 m.
Span of ailerons	7.16 m.
Chord of ailerons	1.02 m.
Wing area, inclusive ailerons	314.50 sq.m.
Area of each aileron	7.25 sq.m.
Span of tail planes	9.00 m.
Maximum chord of stabilizers	1.60 m.
Maximum chord of elevators	0.72 m.
Gap of tail planes	2.15 m.
Area of stabilizers	20.00 sq.m.
Area of elevators	5.00 sq.m.
Area of vertical fins	7.05 sq.m.
Area of rudders	4.02 sq.m.

Wing Form—The span of both wings is equal and the chord is the same except for a difference of some centimetres in the centre section. There is no stagger.

The upper wings have no dihedral, and the lower wings only have a dihedral outside the center section, but this is quite marked.

The incidence is thus approximately 0.45 m. in the 4.5 m. of the total chord, or about 1 in 10.

The wings decrease in curvature towards the tips, and it is possible that the incidence decreases correspondingly, though this could not be ascertained.

As to the wing curve, this recalls on a larger scale that of the 1916 type Aviatik C. It is chiefly noteworthy for having a nearly complete semi-circular leading edge, (Fig. 4) and a relatively slight comber, which necessitates its setting at a considerable angle of incidence. Its maximum thickness is 0.22 m.

Wing Spars.—There are two main spars which are true girders, and a third spar, gutter-shaped and placed on its side, which holds the ribs .75 m. from their ends. In the upper planes this only runs as far as the beginning of the ailerons. The aileron spar, also of a gutter section, supports the aileron hinge and is placed about a meter from the trailing edge.

Both of the true wing spars cross the body at their respective levels. The front spar is secured to the top of the lower body longeron by eight bolts. The rear spar comes flush with the longerons, to each of which it is united by a heavy spar-box of a T shape, which spar-box also serves for the fixing of the rigging cables.

By this continuity across the body it is possible to dispense with special compression tubes, and the position of the lead-

ing spar of the wing permits the existence below it of the metal cross-bracing of the body, while the rear spar itself fulfils the purpose of a similar cross member.

Each of the spars is composed of three pieces. The rear spars are assembled all three in a straight line, but the front spars, outside the engine cabanes, are set back in the arrow shape, and only the spars of the center section are in a straight line. As regards the lower wings, both spars are assembled to give a dihedral.

directions, and the rear spars in thickness only. But the front spars are also thinned down on their upper side as well as lower side, while the rear spars are only thinned on the lower face, in such a way as to provide a more marked raising of the wing surface towards the extreme rear angle of the lower wings, as well as the upper, in the latter of which this wash-out is prolonged by the aileron.

As may be seen in Fig. 8, each spar forms a double box composed of seven grooved pieces which are assembled, glued and

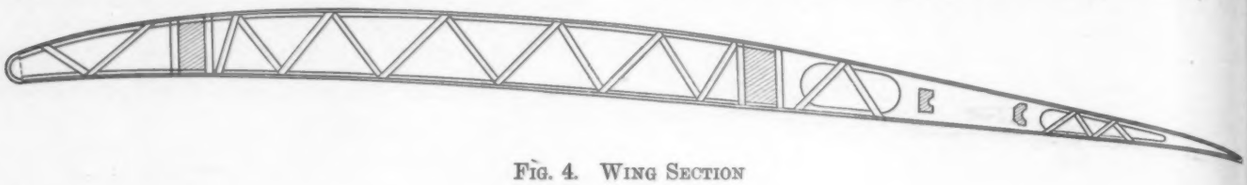


FIG. 4. WING SECTION

This division into three parts does not cut the spar up too much and proportions the length very well, contrary to what would have happened if the spars had been arrowed right up to the axis of the machine.

Moreover, the straight center section, which has already been applied to all German twin-engine machines without exception, is evidently necessary to give the under carriage and the engine cabanes a foundation which is neither oblique nor inclined in either direction.

The three portions of each spar terminate in a rectangular section and are brought together in a powerful collar by strong bolts lying in the direction of the span.

The height of the spars is as follows: Front upper spar 143 to 149 mm., front lower spar 140 to 144 mm., rear upper spar 162 to 167 mm., rear lower spar 161 to 155 mm.

These dimensions are maintained to within 0.6 or 0.7 m. of the wing tip, though on each side of the interplane struts the width of the spars, and not their height, has been thinned down for almost a third of their length.

This width which is normally as follows: 78 mm. to the

reinforced on the two sides by one or two layers of ply-wood, then wrapped with fabric in a spiral before placing the ribs in position. At the points of attachment and at the centre they are left solid. The upper spars, as well as being larger, especially the rear spar, are made of ash, and the lower ones of spruce.

The little supplementary spars are of spruce. The leading edge is a semi-circle of spruce.

Ribs.—Outside the center section where they are perpendicular to both edges, the ribs form with the leading edge and with the front spar an obtuse angle on the side of the body and acute on the opposite side, while they are perpendicular to the rear spar and trailing edge. The same is true of the compression tubes situated between the bases of the interplane struts.

All measurements confirm the fact that the ribs and the bases of the interplane struts are parallel to the axis of the machine and that the arrow of the wings only exists on the leading edge. The construction of the ribs recalls that of the Handley-Page, also of certain Albatroses, and specially that of the framework of the Zeppelin airships.

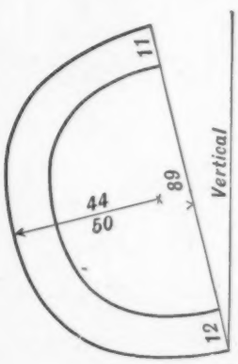


FIG. 5. LEADING EDGE PIECE OF WING

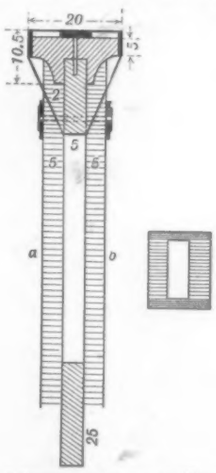


FIG. 6. HORIZONTAL AND TRANSVERSE CROSS SECTION OF RIB

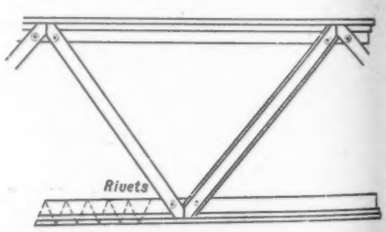


FIG. 7. LONGITUDINAL CROSS SECTION OF RIB

upper front spar; 91 mm. to upper rear spar; 62 to the lower front spar and 89 mm. to the lower rear spar, changes quickly from 78 mm. to 72 mm., from 91 mms. to 85 mms., from 62 mms. to 56 mm. and from 89 mm. to 83 mm., for 1.7 m. of the span in a length of 5.2 m.

Then, by an equally abrupt reversal, they return to the original dimensions which they maintain for 1.9 m. of their length in 5.8 m., returning afterwards to the reduced section for 2 m. of the length, and afterwards going back to the larger dimension at 1.9 m. from the external interplane struts.

Towards the tips, besides this reduction, the section of the spars diminishes progressively for 0.6 to 0.7 ms. in the following manner:—For the upper front spar down to 75 × 75 mm., for the upper rear spar 83 wide × 63 mm. high, for the lower front spar 75 wide × 55 mm. high, for the lower front spar 83 wide × 60 mm. high.

These figures show that the front spars are reduced in both

The top and bottom flanges are glued and nailed to a central web, also in spruce, which is bedded into the flange. Webs in the form of double laths unite the opposite flanges, and in the case of those in compression are made into boxes by the addition of three-ply strips (Fig. 6). They are disposed in zig-zags and fixed to the web of the rib by duralumin rivets.

All these wooden elements are glued, while the ribs are nailed to the spars. Everything except the ply-wood is made of spruce. The trailing tip of the rib is sheathed in a square thimble of thin brass. The trailing edge of the wing is held by a simple piano wire which goes through this thimble.

The distance between the ribs, which is enormous, varies from 0.565 m. to 0.43 m. It is less near the airscrews.

Between two neighboring ribs a flat lath, 15 by 10 mm., extends to the leading edge above the front spar to maintain the shape of the fabric.

On top of each rib the fabric carries a strip of braid glued

outside. It is fixed to the ribs by a thread which passes over this tape and on top of the lot is glued a strip of fabric 3 to 4 cm. in width.

Between the spars two series of bands pass alternatively over and under the ribs of the flanges to which they are nailed, maintaining the position of the ribs laterally. Exactly in the middle between the interplane struts two ordinary ribs are much closer together than the others, being 0.15 m. apart. They maintain the distance between the longerons against the compression which is exercised by the secondary cross-bracing in the vicinity of these ribs.

Bracing.—The wings have a double system of cross-bracing, one between the bases of the struts, which consists of thick cables, and the other of simple 3 mm. piano-wire joined to the ends of the twin ribs which are placed half-way between the struts.

These wires, by a curious disposition in crossing the spars, penetrate through them obliquely, as shown in Fig. 9, and they are connected to a simple nut and bolt arrangement. In the spruce block situated in the external angle between the rib and spar they are fixed solely by the pull of the turnbuckle.

The long cable bracing is fixed to the extremities of the compression tubes. This extremity is fixed to the spar by two lateral lugs, pierced with holes, to which are attached the cables and wires of the cross-bracing.

Compression Tubes.—These are situated between the extremities of the interplane struts, and between the engine cabanes. They serve at the same time to maintain the distance against the incidence bracing. Given that there are two for the base of each cabane, and a single one for the single summit, there are altogether ten in the lower plane, and eight in the upper plane, a number which is frequently surpassed in the small German airplanes.

The tubes are round, 50 mm. in diameter, for those at the summit of the cabane, 45 mm. at the base of the cabane and decreasing toward the tips, from 40 mm. down to 12 mm. between the external masts.

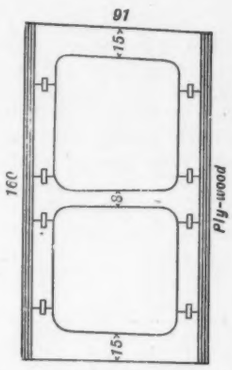


FIG. 8. CROSS SECTION OF WING SPAR

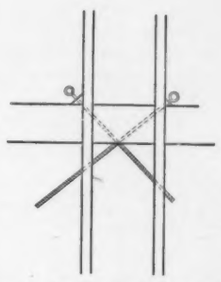
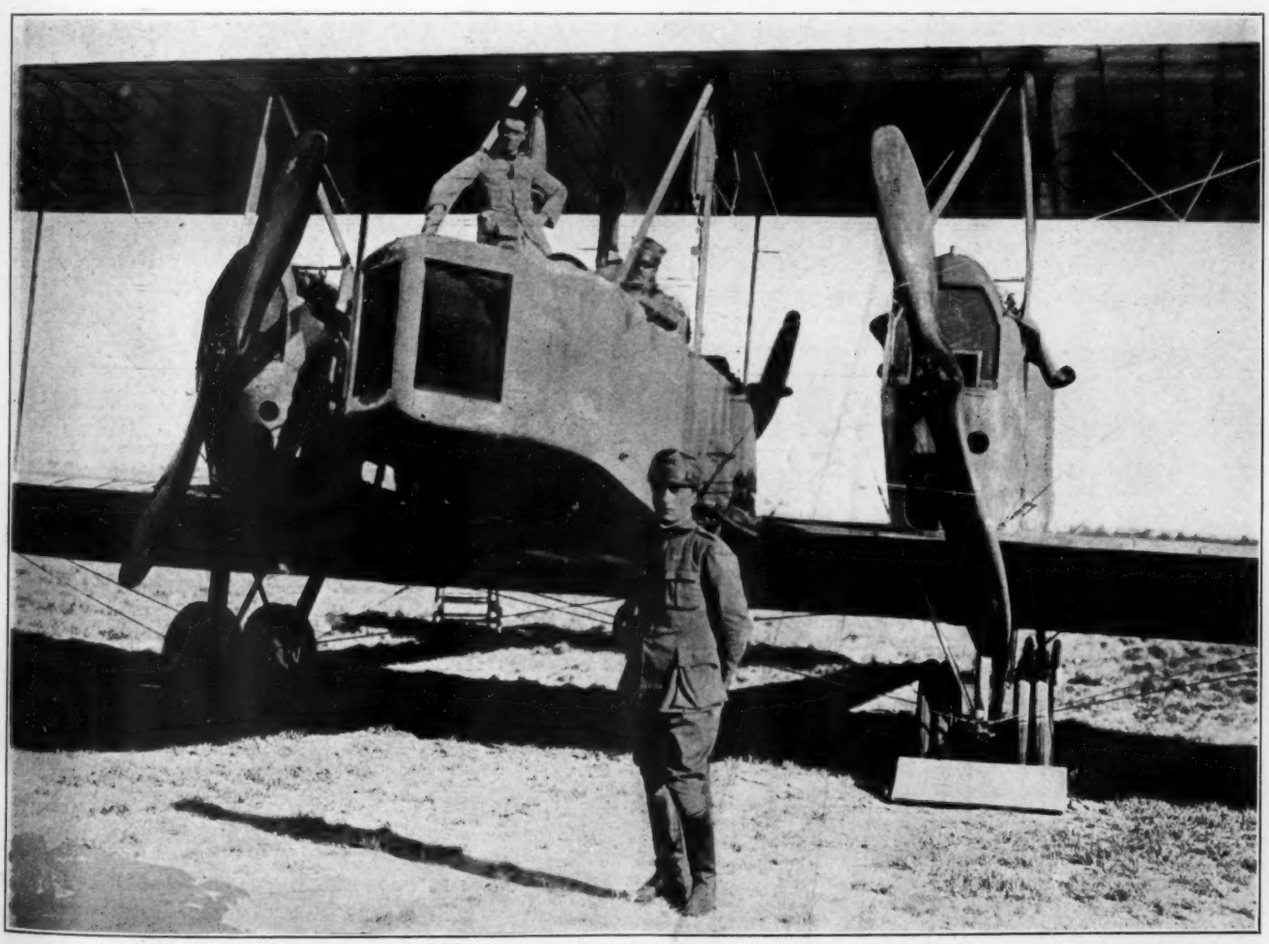


FIG. 9. DETAIL OF INTERNAL WING BRACING

(To be Continued)

America's Largest Bombing Airplane



MIDWING PORTION OF THE LIBERTY-CAPRONI, SHOWING NACELLE WITH PUSHER ENGINE AND SEPARATE TRACTOR BODIES

(C) *Committee on Public Information*

Cost of the Air Mail Service in June and July

The monthly tabulated report on the operation and maintenance of the Aerial Mail Service has just been issued by the Post Office Department for June and July, and is reprinted herewith.

Just as in the report covering the first fortnight of operation of the Aerial Mail Service, which was reproduced in the Aug. 1, 1918 issue of AVIATION AND AERONAUTICAL ENGINEERING, depreciation of the material is not estimated for lack of convincing data, but is reflected in the items under repairs, parts and labor. Items for rent, light, power, miscellaneous, dead time of pilots and hangar men, shop time of mechanics, departmental overhead charge, and interest on investment, all of which are not directly apportionable to individual machines, are prorated equally between all of the airplanes.

It may be noted that in June the Aerial Mail Service had eleven airplanes in operation, as against nine for the first fortnight, six of which were fitted with the Liberty-12, and five with the 160 hp. Hispano-Suiza, as against nine machines in operation during the first fortnight, three of which were engined with the Liberty-12, and six with the Hispano-Suiza. The Liberty machines are designated by the series 39, and the Hispano-Suiza machines by the series 38.

OPERATION AND MAINTENANCE, JUNE, 1918

Airplane No.	Gas.	Grease and Oil	Office Force	Motor Cycles, Trucks	Rent, Light, Fuel, Power, Telephone, and Water	Misc.	Pilots: Actual Time	Pilots: Dead Time	Hangar Men: On Plane	Hangar Men: Miscellaneous	Mechanics: On Plane	Mechanics: Shop Time	Repairs and Accessories	Interest on Investment	Departmental Overhead Charge	Total
38275...	$93.57	$24.60	$26.55	$79.79	$16.85	$2.27	$49.22	$42.94	$97.51	$17.95	$71.27	$15.52	$137.13	$64.94	$31.81	$771.92
39362...	27.70	5.03	15.84	79.79	16.85	2.27	15.40	42.94	53.76	17.95	97.04	15.52	1312.40	64.94	31.81	1799.24
39363...	6.00	.75	9.09	79.79	16.85	2.27	—	42.95	8.75	17.96	26.87	15.52	25.23	64.93	31.82	348.78
39364...	1.95	—	9.09	79.79	16.85	2.27	—	42.95	8.75	17.96	30.29	15.52	1.43	64.93	31.82	323.60
39365...	85.20	12.70	15.84	79.79	16.86	2.27	64.40	42.95	53.76	17.96	114.24	15.52	12.70	64.93	31.82	630.94
39366...	271.15	45.36	15.84	79.79	16.86	2.28	193.32	42.95	53.76	17.96	214.42	15.52	351.25	64.93	31.82	1417.21
39367...	20.10	1.08	15.84	79.79	16.86	2.28	7.00	42.95	53.76	17.96	90.47	15.52	644.38	64.93	31.82	1104.74
38262...	18.50	5.40	6.75	79.78	16.86	2.28	—	42.95	45.01	17.96	61.30	15.52	667.08	64.93	31.82	1074.14
38274...	132.93	37.19	17.49	79.78	16.86	2.28	91.55	42.95	88.76	17.96	33.84	15.52	95.83	64.93	31.82	769.69
38276...	90.36	33.99	17.46	79.78	16.86	2.28	113.15	42.95	88.76	17.96	91.64	15.52	224.15	64.93	31.82	931.61
38278...	93.99	32.01	17.46	79.78	16.86	2.28	69.39	42.95	88.76	17.96	79.20	15.53	97.92	64.93	31.82	750.84
Total..	$839.45	$198.11	$167.25	$877.65	$185.42	$25.03	$603.43	$472.43	$641.34	$197.54	$910.58	$170.73	$3569.50	$714.25	$350.00	$9922.71

OPERATION AND MAINTENANCE, JULY, 1918

Airplane No.	Gas	Grease and Oil	Office Force	Motor Cycles, Trucks	Rent, Light, Fuel, Power, Telephone, and Water	Miscellaneous	Pilots: Actual Time	Pilots: Dead Time	Hangar Men: On Plane	Hangar Men: Miscellaneous	Mechanics: On Plane	Mechanics: Shop Time	Repairs and Accessories	Interest on Investment	Departmental Overhead Charge	Total
38262	$77.34	$27.95	$16.94	$98.51	$15.73	$57.44	$61.90	$43.73	$84.32	$22.00	$45.12	$20.35	$66.77	$71.42	$55.30	$764.82
38274	143.72	47.04	16.95	98.51	15.73	57.44	98.06	43.74	84.32	22.00	136.00	20.35	695.58	71.42	55.30	1,606.16
38275	49.20	14.29	16.94	98.51	15.73	57.44	39.34	43.74	84.33	22.00	29.53	20.35	757.83	71.42	55.30	1,375.95
38276	46.08	16.49	16.94	98.51	15.74	57.44	33.70	43.74	84.33	22.00	73.39	20.35	18.40	71.43	55.30	673.84
38278	124.76	41.69	16.94	98.51	15.74	57.44	116.62	43.74	84.33	22.00	108.35	20.35	67.22	71.43	55.30	944.42
39362	57.60	4.60	17.67	98.51	15.74	57.44	11.08	43.74	63.46	22.00	60.20	20.35	263.55	71.43	55.30	862.67
39363	150.30	9.46	17.66	98.51	15.74	57.45	84.32	43.74	63.10	22.01	117.08	20.35	2.89	71.42	55.30	829.33
39365	130.30	18.79	17.66	98.51	15.74	57.45	94.20	43.74	63.10	22.01	117.26	20.35	202.34	71.42	55.30	1,028.17
39366	113.70	10.39	17.66	98.51	15.74	57.45	94.36	43.74	63.09	22.01	106.56	20.35	262.23	71.43	55.30	1,052.52
39367	75.80	7.99	17.66	98.51	15.74	57.45	58.16	43.74	63.09	22.01	88.54	20.35	167.81	71.43	55.30	863.58
Totals.	$968.80	$198.69	$173.02	$985.10	$157.37	$574.44	$691.74	$437.39	$737.47	$220.04	$882.03	$203.50	$2,504.62	$714.25	$553.00	$10,001.49

SERVICE AND UNIT COST, JUNE, 1918

Airplane No.	Gal. of Gas.	Total time run hr.	Total time run min.	Total miles run	Miles run per gal. of gas.	Cost per hour	Cost per mile
38275....	307	25	33	1617½	5.26	$30.21	$.4772
39362....	94	3	11	300	3.19	565.20	5.9974
39363....	20	—	45	74	3.70	465.04	4.7132
39364....	6½	—	24	16	2.46	808.99	20.2250
39365....	284	16	07	1540	5.42	39.14	.4097
39366....	914½	49	57	4724	5.16	28.37	.3000
39367....	67	1	08	87	1.29	974.77	12.6981
38262....	55	—	—	—	—	—	—
38274....	435	33	58	2295	5.27	22.66	.3353
38276....	296	26	49	1747	5.90	34.73	.5332
38278....	308	25	59	1755	5.69	28.90	.4278
Total....	2787	183	51	14155½	5.07	53.97	7.009

SERVICE AND UNIT COST, JULY, 1918

Airplane No.	Gallons of Gasoline	Total Time Run Hr.	Total Time Run Min.	Total Miles Run	Miles Run per Gallon of Gasoline	Cost per Hour	Cost per Mile
38262	254	21	18	1,460	5.74	$35.90	$.5238
38274	471	35	44	2,450	5.20	44.95	.6555
38275	162	13	07	710	4.38	104.90	1.9379
38276	151	9	05	630	4.17	74.18	1.0695
38278	409	27	18	2,063	5.04	34.59	.4577
39362	192	5	13	450	2.34	165.36	1.9170
39363	501	19	11	1,710	3.41	43.23	.4849
39365	441	20	21	1,820	4.12	50.52	.5649
39366	379	23	11	2,093	5.52	45.39	.5028
39367	251	14	25	1,215	4.84	59.90	.7107
Totals..	3,211	188	53	14,601	4.54	$52.95	$.6849

Aeronautical Patents

ISSUED JULY 2, 1918

1,270,945—To Nykyfor Hawrylasz, Tarentum, Pa. Airplane protector.
1,270,971—To George E. Richmond, Austin, Tex. Airship.
1,271,213—To Paul Petres, Astoria, N. Y. Dirigible propeller-mounting.
1,271,480—To Lewis Kulcsar, Punxsutawney, Pa. Airplane.

ISSUED JULY 9, 1918

1,272,333—To Ralph J. Daly, Philadelphia, Pa. Aerial mine.
1,272,211—To Godfrey Lowell Cabot, Boston, Mass. Launching mechanism for aircraft.
1,271,896—To Robert A. Higgins, Henderson, Colo. Aircraft.
1,272,058—To Herman T. Kraft, Akron, Ohio. Suspension-patch for

ISSUED JULY 16, 1918

1,272,373—To Randolph Brunson, East Orange, N. J. Aircraft construction.
1,272,712—To J. Gabriel Recuero, Panama, Panama. Airplane.
1,272,766—To Benno J. Bengartz, Brooklyn, N. Y., assignor to United States Aircraft Corporation, Inc., New York. Aviator's instruction machine.
1,272,797—To Frederick W. Gore, Huntington, N. Y. Aircraft.
1,272,805—To Herbert J. Hogan, Los Angeles, Cal. Airplane.
1,272,846—To Thomas O. Perry, Oak Park, Ill. Aircraft for mechanical flight and automatic soaring.

ISSUED JULY 30, 1918

1,273,827—To Guy M. Cook, Golconda, Nev. Airship.
1,273,836—To Warren S. Eaton, Plainfield, N. J. Hydroaeroplane.
1,273,950—To Robert F. J. Teltzrow, Beaver Dam, Wis. Flying machine.
1,274,037—To John C. Hasbrouck, Jr., New York. Flight retarder or airplane brake.
1,274,207—To Jozef Sordyka, Grand Rapids, Mich. Balloon construction.
1,274,314—To Lucja Ogrodniczek, Scranton, Pa. Aviator's saver.

The Climb of an Airplane

By Lieut.-Col. V. E. Clark, A.S.

I prepared the "Climb" Charts in order to have at hand a means of instantly arriving approximately at the climb and rate of climb of an airplane at any altitude.

The sloping lines are drawn for the various values of the weight—power ratio of the airplane (pounds per horsepower developed at sea level).

The charts apply to single-engine biplanes of the tractor type, the general type recognized as standard at the present day, equipped for military functions. For the computations, it has been assumed that the engine is run at full throttle at all altitudes and that the power developed varies approximately as the barometric pressure, or, more exactly, as indicated on the Power-Altitude Curve on chart (Fig. 1). It has also been assumed that the airplane is flown at all times at the angle for maximum climb per unit of time. The surface loading assumed was 7.25 pounds per square foot; the wing section —U. S. A. 14.

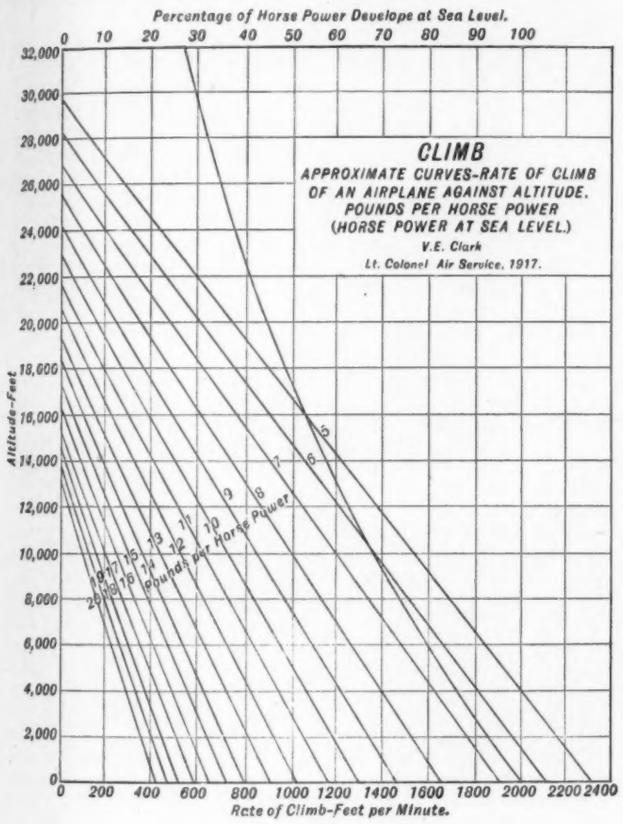

Percentage of Horse Power Develope at Sea Level.
0 10 20 30 40 50 60 70 80 90 100
CLIMB
APPROXIMATE CURVES-RATE OF CLIMB OF AN AIRPLANE AGAINST ALTITUDE. POUNDS PER HORSE POWER (HORSE POWER AT SEA LEVEL)
V.E. Clark
Lt. Colonel Air Service, 1917.
Pounds per Horse Power
Altitude-Feet
32,000 30,000 28,000 26,000 24,000 22,000 20,000 18,000 16,000 14,000 12,000 10,000 8,000 6,000 4,000 2,000 0
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
Rate of Climb-Feet per Minute.

FIG. 1

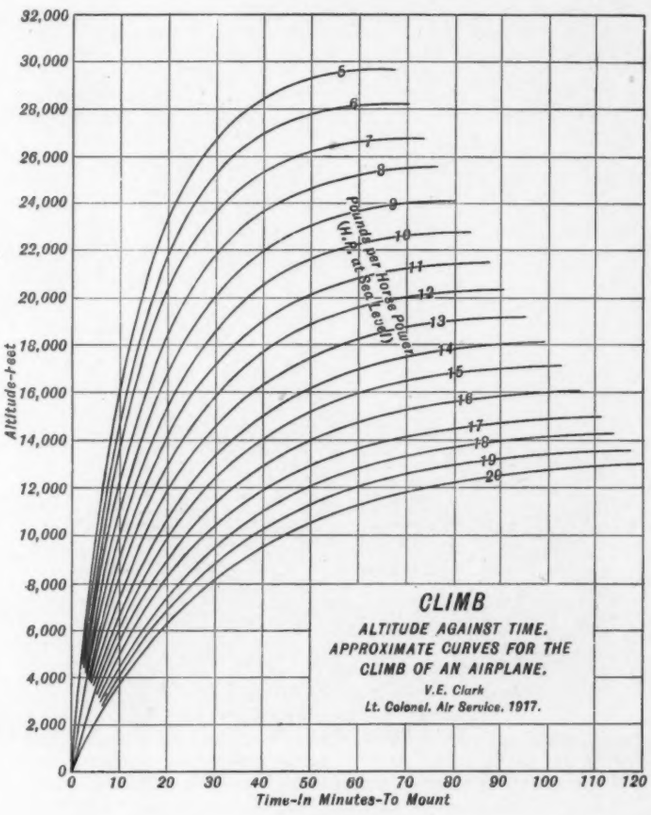

CLIMB
ALTITUDE AGAINST TIME. APPROXIMATE CURVES FOR THE CLIMB OF AN AIRPLANE.
V.E. Clark
Lt. Colonel. Air Service. 1917.
Pounds per Horse Power (H.P. at Sea Level)
Altitude-Feet
32,000 30,000 28,000 26,000 24,000 22,000 20,000 18,000 16,000 14,000 12,000 10,000 8,000 6,000 4,000 2,000 0
0 10 20 30 40 50 60 70 80 90 100 110 120
Time-In Minutes-To Mount

FIG. 2

It must be remembered that these charts are only intended to give a very rough approximation of the climb and rate of climb.

Many considerations other than the weight-power ratio influence the rate of climb.

The design of the propeller is the most important factor next to the weight-power ratio. The calculations for the charts were based upon the assumption, in each case, that the propeller is designed upon the primary consideration of developing its maximum efficiency when the airplane is flying at its maximum horizontal speed at an altitude .7 of its absolute ceiling. A propeller of lower pitch would, in each case, increase the rate of climb at all altitudes, and a smaller diameter would steepen the slope of the rate of climb curve, raising the ceiling.

Again, aside from the weight-power ratio, the airplane which, as a complete system, has the best maximum value of $\frac{L^{3/2}}{D+R_p}$ will have the best rate of climb at all altitudes and will have the steepest rate of climb slope, and the highest ceiling. L = Lift of complete system; D = Drag of main sustaining surfaces; R = Parasite Resistance. The maximum value of $\frac{L^{3/2}}{D+R_p}$ usually occurs at the angle of incidence which give a K_y of value between .65 and .75 of maximum K_y.

One method of increasing the factor $\frac{L^{3/2}}{D+R_p}$ is to increase the area of the sustaining surfaces, thereby decreasing the surface loading.

Another way to accomplish this is to use a wing section similar to the U. S. A.—2, 3 or 6, rather than a good speed range section, similar to, say, U. S. A.—14, 15, 16 or 17.

Stream-lining and cleaning up a ship increases this factor by reducing R_p in the denominator.

The use of an engine with very high compression at sea level—so high as to make it a delicate matter to use full throttle at low altitudes—will naturally steepen the rate of climb curve and raise the ceiling in all cases. The installation of a mechanical device or the development of fuel may steepen the Power-Altitude Curve, thereby steepening the rate of climb curve.

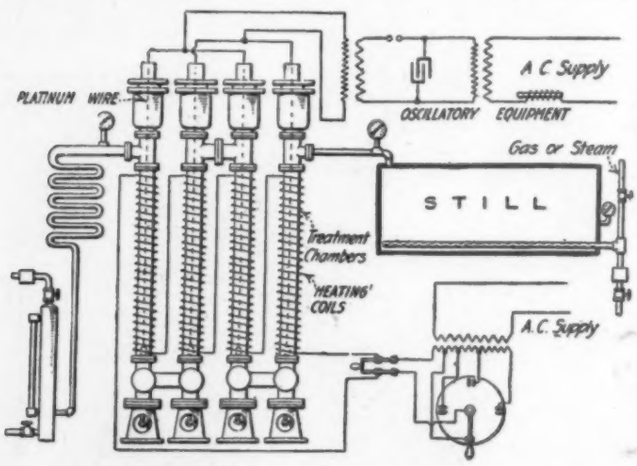
General Kenly on Joint Board

Major General W. L. Kenly, Director of Military Aeronautics, has, by direction of the President, been detailed as a member of the Joint Army and Navy Board on Aeronautic Cognizance. General Kenly takes the place formerly held by Major General G. O. Spuier, Chief Signal Officer.

Synthetic Gasoline

The rapid increase in the world's aircraft, and in the many other machines requiring gasoline as motive power, must eventually result in there being a very acute shortage of this fuel, unless the engines can be arranged to use heavier oils equally well, or a synthetic gasoline be produced. Other substances in great demand have been satisfactorily made by uniting the elements, and it is believed that our enemies have practiced this form of production to a great extent, however their extensive use of alcohol has apparently so far enabled them to overcome the difficulties due to any shortage of gasoline.

Crude petroleum, as obtained from the wells, is split up by distillation into various grades of oil, and the lightest product used for fuel is known as gasoline; this distils over at a temperature of about 60 to 150 deg. The lightest products with lowest boiling points are sometimes used for increasing the volatility of heavier spirits, and the gaseous hydrocarbons,



STILL FOR PRODUCING SYNTHETIC GASOLINE

which are generally given off by wells, and are called natural gas, are condensed and used for the same purpose. The lighter the gasoline the more easily it will volatilize in air at ordinary temperatures, and thus readily form an explosive gaseous mixture for internal combustion engines.

Light grade gasoline requires appreciably less heat for its conversion into a gaseous state than heavier fuel, and owing to its low latent heat of vaporization the tendency of the formation of snow in carbureters is reduced, also less attention need be given to the carburation. It is well known that owing to the very great demand for gasoline the temperature range of its distillation has been enlarged, and now much heavier grades of this fuel have to be used in engines. When synthetic gasoline is produced on a commercial scale, there is the possibility of obtaining a sufficient supply of the light-grade fuel, which will be a great advantage for aero engines.

From a chemical standpoint gasoline mainly consists of the elements carbon and hydrogen, and as it is not a pure chemical compound, but a mixture of a large number of compounds, its properties cannot be definitely stated as they vary in each different grade. A good one is composed of a probable blend of hexane (C_6H_{14}), heptane (C_7H_{16}), and octane (C_8H_{18}). These compounds have an almost indifferent character, and refuse to take on more hydrogen or chemically to unite with any of their associates, and resist the action of most re-agents at low temperatures.

Natural gas is composed largely of methane (CH_4), which occupies a place at the beginning of the series of hydrocarbon compounds, and is the simplest of the gasoline group. The mixing of this when condensed with heavier hydrocarbons to obtain an increased quantity of light fuel oil has already been mentioned. Now if sufficient methane, or hydrogen gas, could be chemically united in proper proportions and form to certain of the heavier oils, synthetic gasoline could be produced.

Already it is known that the increase in percentage of hydrogen necessary to convert some of the heavier hydrocarbons into the lighter and lower boiling point compounds is surprisingly small. One of the earliest experiments along this line demonstrated that this was feasible by converting paraffin having a specific gravity of 0.81 into gasoline of 0.715 sp. g. The apparatus was very crude, as the still was made of a piece of three-inch pipe with ends closed by screwed-on caps.

The gas and oil vapors were subjected to high voltage, alternating, high-frequency current in chambers made of one-inch diameter pipe, which had been reamed and plugged, the ends of which were fitted with modified spark plugs which served to lead the current through a fine platinum wire. This wire passed through the center of the pipe from end to end, and, when connected to the high-frequency coil, subjected the gas and oil vapor passing through the pipe to a silent electric discharge alternating between the central electrode and the pipe at right angles to the direction of the flow of gas.

This experiment was carried out at high pressures and temperatures, but later ones with larger and better equipment proved that a very high frequency was necessary to obtain low boiling-point compounds, and that increasing the frequency would raise the specific gravity and lower the vaporization temperature. Stills for these equipments were made of 4-in. diameter extra-heavy pipe, and at 60 volts they required about 40 k.v.a., the frequency being sixty per second. The electrical generating apparatus consisted of a one kilowatt 110 to 25,000 volts step-up transformer, with a variable re-actance in the primary and a variable condenser. The accompanying figure gives a diagrammatic arrangement of an equipment of this type.

In order to avoid the difficulties due to the use of high pressures, attempts were made to produce synthentic gasoline under atmospheric pressure, and it was found that, although equally good products could be obtained as when operating under high pressures, the percentage of conversion was not so great. However, by re-running the residue, which was practically the same density as the original paraffin, an additional conversion of 33 per cent was obtained every time it was run through the still.

The success of these experiments led to the construction of a larger plant, which embodied a step-up transformer for 110-120 to 50,000-100,000 volts, and had a capacity of converting into petrol about 1500 barrels of oil every twenty-four hours. A 78 per cent conversion can be made from paraffin, and it is possible that by increasing the length of the treatment chambers a greater efficiency of conversion will be obtained. Further investigations are being made, and the possibilities of this process are apparently very great, for from the results so far secured it is estimated that, if need be, the output of gasoline can be increased 200 per cent. The cost of this conversion is quite reasonable, the amount of power being the principal item, and this works out at approximately two-pence (4 cents) per gallon of gasoline.—From *Flying* (London).

Book Review

DICTIONARY OF AVIATION. By Robert Morris Pierce. (Languages Publishing Co., New York. 267 pp.)

At the present time two compilations exist in English, both of which may lay claim to authoritative nature. One is the elementary terminology published by the Royal Aeronautical Society in 1914, which is now being revised and enlarged, while the other is the Nomenclature for Aeronautics, which was issued by the U. S. National Advisory Committee for Aeronautics as Report No. 15 of their publications.

Pierce's Dictionary of Aviation was first published by the author in 1911. This is a compilation of quite an ambitious nature, as may be gathered from the size of the book; it is, therefore, to be regretted that the definitions introduced by the author are in many cases quite obsolete and do not correspond to the meaning now given certain well-known terms, such as *aircraft, aviation, ballonnet, seaplane,* etc. Furthermore, there is a large number of terms—*aeropleustic, aerodyne, aviatory, flying-gecko, neossoptile, trochoidal, volator,* to mention but a few—which are never met with in aeronautical works, and appear to be rather within the province of ornithology, not to speak of the curious phonetic spelling employed throughout the text.

Digest of the Foreign Aeronautical Press

The Aeroplane, Aug. 14, 1918

Work of the R. A. F. in the Third Battle of the Somme—The Royal Air Force with the British army in France played a most important part in the recent successes on the Somme.

The destruction by R. A. F. fighting pilots of large numbers of enemy airplanes made the way clear for wholesale attacks by low-flying airplanes upon German infantry, guns and transport, so disorganizing and impeding what might otherwise have been an orderly retreat.

Two complete advanced aerodromes were captured, at one of which was found a five-engined bombing airplane, a type which has been in existence for some time, but not very much in evidence.

At the commencement of the advance on August 8 all the German aerodromes in the sectors attacked were heavily bombed, and, as a result, for several hours not a single German airplane was able to leave them.

Subsequently, the Somme bridges were attacked and a number destroyed by bombs, which resulted in great congestion of enemy traffic at other crossings.

The low-flying airplanes, which were so numerous as to need the greatest skill on the part of the pilots to avoid collisions, paid special attention to the crews of anti-tank guns, to troop trains, balloon teams and staff officers.

The Aeroplane, Aug. 21, 1918

French Aerial Mail Service Inaugurated—A postal service by air was started on August 18 for the first time in France between Paris and St. Nazaire. Airplanes, carrying mails, left Le Bourget Aerodrome, near Paris, shortly after ten, and one of the two machines, the other having had an accident, reached St. Nazaire at 8.30 p. m., after a stoppage at Le Mans. The total distance from Paris to St. Nazaire is some 250 miles.

The air service will shortly become regular and daily, and a Paris-Nice aerial postal service may soon be started with a possible continuation to Rome. The airplanes used are machines which, though quite efficient for this service, are out of date for military use at the front.

The pilots are also men who can no longer be of service at the front. For instance, one is a sergeant-major, who has already been ten times wounded in action, and another is a sergeant who escaped from Germany, where he was a prisoner of war. When the aerial postal service becomes regular, the extra charge for letters by it will be 7½d. per letter.

Letters taken by aerial post are at present wrapped in a narrow red band bearing the words, "By airplane." Very soon the aerial postal service will be working regularly, and a special stamp will be used bearing the effigy of the late Captain Guynemer.

FRENCH POSTAL AIRPLANE, USED ON THE PARIS-ST. NAZAIRE ROUTE—THE MACHINE IS A LEPORT TWIN-TRACTOR, FITTED WITH TWO 150 HP. HISPANO-SUIZA ENGINES

Central News Photo Service

Flight, Aug. 29, 1918

Aerial Mail Service in Morocco—In connection with the inauguration of aerial mails in France, it is pointed out that for over a year airplanes have been officially used in Morocco for linking up the various units. Each sub-division has a squadron at its disposal, the airmen insuring a service between the chief town of the sub-division and distant outposts. They carry the ordinary mails, urgent dispatches, and telegrams impossible to send by wire. Finally they see that certain posts are kept in funds. All these activities are carried out automatically, without interfering with the normal service of the bombing, photographic and patrol squadrons. It is suggested that in future it might be possible, by means of an agreement between the Morocco Protectorate and the government of Algeria, to establish aerial postal communication with the great North African colony, which would benefit no less than Morocco by the economy in time and expense thus assured.

After-the-War Flying—Mr. Handley Page, speaking at a meeting on August 7 on "After-the-War Flying," said that upon the declaration of peace it would be possible to commence an air service between London and Marseilles, with a single stop at Paris for an overhaul and the taking in of petrol. The coming of peace would find tremendous facilities existing for the manufacture of airplanes, and an outlet must be found for these vast organizations which had been brought together at great expense. Examining the advantages which would attend the use of the airplane by the Post Office, he said that before the war the actual transit of mails from London to Constantinople took 72 hr. By air the same journey could be effected in 20 hr. Rome could be reached in 12½ hr. instead of 42 hr. Marseilles in 8 hr. instead of 23 hr. He was convinced that such a service could be run at a profit, both for mails and passengers, at a rate but little in excess of that which was at present in force. He based his calculations on the use of a medium-sized machine making non-stop flights of 400 miles. Each would be provided with two 300 hp. engines, and would carry 4400 lb. of revenue-earning load, in addition to the pilot, mechanic and petrol necessary for a five-hour flight. There would be first-class aerodromes at each end of the route, and another in the middle, completely equipped for overhauling and repairing machines. Second-class aerodromes, with necessary equipment, would be provided every 100 miles, these latter corresponding to the ordinary stations of a railway. He provided for 24 machines, running a minimum service of six machines each way per day. Such a service could be provided for a capital of under £500,000. The annual cost would be under £600,000. The cost per ton mile would work out at 20½d., and the cost per passenger mile to 1.36d. It would be necessary that merchandise should be carried with passengers, if the passenger rate were to be kept down. At the cost of ordinary first-class traveling, every part of the globe would become available to the traveler by airplane. America would become within reach in a day and a half, and to aviators, America was no more distant than Manchester was at the end of the Eighteenth Century. The time would come when an Englishman in New York would see his London paper the morning after its publication, and the same thing would apply to the whole continent of Europe. He agreed that reliability would be everything.

Sir Joseph Ward said that he had decided, as Postmaster-General of New Zealand, to introduce airplanes in New Zealand to carry the mails from one end of the country to the other as soon as the war was over.

As an indication of the degree of stability now attained with some of our airplanes, the following test has been recently carried out: A pilot climbed to a sufficient height and then stopped his engine, and took his hands off the controls, merely keeping his feet on the rudder bar. He steered for an aerodrome 20 miles away, and, except for keeping her straight, he let the airplane do what she liked. She traveled the whole 20 miles as steadily as a bicycle coasting down a long, straight and gentle hill. Of course, the pilot had to take hold of the control-stick to land the machine in the aerodrome, but except for that and the steering the airplane made the whole journey by herself. If a pilot gets into difficulties when "stunting" a stable airplane, all he has to do is to stop the engine and leave the machine to itself. Whatever her position may be at the time, she will quickly right herself and begin to glide. A very stable machine is not quick at maneuvering, nor is it very speedy.

ASSORTMENT OF BRITISH "PILLS" DESTINED FOR GERMANY
British Official, from Feature Photo Service

News of the Fortnight

Aircraft Manufacturers Meet

The September meeting of the Manufacturers' Aircraft Association included a trip in automobiles from the Biltmore Hotel, New York, to the plant of the L-W-F Engineering Company, at College Point, L. I., inspection of that plant, which is in substantial production of naval flying boats, a trip on I. M. Uppercu's yacht to Greenwich, Conn., and lunch and dinner at the Greenwich Country Club as the guests of Judge W. Benton Crisp, counsel for the association, and J. G. White, president of the Springfield Aircraft Corp.

During intervals between business affairs the members of the association and their guests had an opportunity to enjoy one of the finest golf courses in the country at the Greenwich Club, as well as the tennis courts. Judge Crisp presided at the dinner in the evening and introduced several speakers who were not connected with the association. Professor Joseph S. Ames, Johns Hopkins University, a voting trustee of the association and a member of the National Advisory Committee for Aeronautics, pointed out some of the fundamental difficulties with which the aircraft program has had to contend. George H. Houston, president of the Wright-Martin Aircraft Corp.; J. G. White, J. M. Harlan, president of the Breese Aircraft Co., and one or two other speakers alluded to the necessity for better public understanding of what the manufacturers have accomplished and the necessity for a fixed policy, continuing orders, and confidence in the manufacturers.

The hospitality of President Uppercu, of the Aeromarine Plane & Motor Co., in extending the use of his yacht, and of Judge Crisp and Mr. White in providing entertainment at the Greenwich Country Club, was highly appreciated by the association and its guests.

The following members and guests were in attendance:

I. M. Uppercu and E. de B. Newman, Aeromarine Plane & Motor Co.; Captain Hall, U. S. N.; Frank H. Russell and Mr. Davis, the Burgess Co.; W. B. Stratton and F. L. Faurote, Curtiss Aeroplane & Motor Co.; H. E. Talbott, Dayton-Wright Airplane Co.; Albert H. Flint, Parker Sloane and J. M. Fitzgerald, L-W-F Engineering Co.; H. B. Mingle, E. E. Pennywell, R. C. Taylor, C. H. Day, J. G. Masters and A. Milne, Standard Aircraft Corp.; J. G. White, Mr. Marchant, Mr. Rose, Mr. Curwen and Mr. Rolland, Springfield Aircraft Corp.; B. S. Foss, Sturtevant Aeroplane Co.; W. F. Thomas, Thomas-Morse Aircraft Corp.; George H. Houston and Richard F. Hoyt, Wright-Martin Aircraft Corp.; Leon Rubay and Mr. Turner, the Rubay Co.; George Newbold, AVIATION; W. Benton Crisp and Joseph S. Ames, voting trustees, Manufacturers' Aircraft Association; S. S. Bradley, general manager, and W. V. Taylor, Manufacturers' Aircraft Association; Captain Berger, Aircraft Promotion Board, New York; E. C. Lufkin, president Te as Co.; Thomas F. Cole, Earle D. Babst, president of the American Sugar Refining Co.; L. R. Wilfley, E. H. Hooker, Hooker Electric Chemical Co.; W. G. Birge, president Air Reduction Co.; Duane Armstrong, P. G. Gossler, A. B. Leach & Co., W. H. Childs, president Barrett Co.; W. H. Truesdale, president D., L. & W. R. R.; Colonel Robert B. Baker, George Foster, Andrew W. Rose, Hon. Thomas L. Feitner, Robert Adams, De Veoux Powell, Henry B. Carhart, Frederick L. Childs, J. M. Harlan, Mr. Morrison, T. M. Hodgens and William H. Temple.

New Goggle Lenses

Following experiments with lenses for air pilots' glasses, the Medical Research Board of the Division of Military Aeronautics announces that it has been able to effect the casting of certain substances in thin sheets which, while not glass, can be used as such, and may afford a practical substitute for it in goggles. This substance has been on the market for some time, but the company which makes it has not up to the present been able to cast it in the right strength and thickness suitable for goggles.

Under the direction of the Medical Research Board, thin sheets of the material have been produced which not only are of the proper texture and thickness, but can be ground and polished. The substance is hard and non-inflammable and insures practically a non-shatterable lense for the protection of the pilot's eyes.

Liberty-Caproni Officially Tested

The first American-built Caproni bomber, which was constructed by the Standard Aircraft Corporation, of Elizabeth, N. J., successfully completed its official trial flights on September 21, at Hazelhurst Field.

The machine is a three-engine biplane of 78-ft. span, with a pusher *nacelle* and two tractor bodies. It is fitted with three Liberty-12 engines, each developing 400 h.p., so that its power plant aggregates 1200 h.p. Its normal complement is three men and its armament consists of three machine guns mounted on the nose of the *nacelle*. The fuel tanks have a capacity of 350 gallons, sufficient for a five-hour flight.

With a useful load of 2400 pounds the Caproni bomber has a designed speed of 105 miles an hour at an altitude of 10,000 feet, and can climb to that level in 14½ minutes. The total weight of the machine, fully loaded, is 11,400 pounds.

During its official trial flights, in which it was piloted by Captain Ugo D'Annunzio and Lieutenant Giuliano Parvese, both of the Royal Italian Flying Corps, and carried Captain H. Harris, A. S., as an observer, the machine fully loaded reached an altitude of 14,000 feet.

Major General J. Franklin Bell, commander of the Eastern Department, made an official observation of the flight, and Colonel Brant, of the Department of Military Aeronautics, was delegated by Major General William L. Kenly, in command of the department, to compile a report. John D. Ryan, Second Assistant Secretary of War, in charge of the aviation program, was represented by J. Gilmore Fletcher and William Erb. G. Bevione, head of the Italian aeronautic mission, with a number of Italian, French and Canadian officers, observed the flight so that they could make reports to their superiors upon the efficiency of the Caproni as a bombing machine.

Before the official flight 500 cadets from the ground school of the Aviation Section at Princeton University arrived. They were permitted to study the construction of the machine and its engines, and were taken to all the hangars at Hazelhurst Field to examine the De Havilands, the Nieuports and other planes there.

Martin Drives Auto with Natural Gas

On September 22, "gasless Sunday," Glenn L. Martin, vice president of the Glenn L. Martin Co., drove his eight cylinder Cadillac through the streets of Cleveland. The fuel was natural gas, which was contained in a gas bag 5 feet in diameter by 12 feet long, with a capacity of 200 cu. ft., estimated sufficient to propel the automobile twenty-five miles at fifteen miles per hour.

A copper tube leads from the bottom of the bag in front down into the hood and carbureter. The tube has a cut-off over the left forward finder, with a connection for attaching by gas hose to any accessible gas jet or outlet. To fill the bag from an ordinary fixture takes about forty minutes.

The observance of "gasless Sundays" east of the Mississippi is directly responsible for this European innovation, which will be used on Sundays only in necessary trips to the Martin airplane plant. While the War Industries Board's ruling does not apply to cars engaged on Government business, Mr. Martin prefers to avoid any thoughtless criticism and at the same time point the way toward further gasoline conservation during the war.

The Goodyear Company produced the gas bag. As the gas is consumed elastics take up the slack in the bag. Mr. Martin has a design for an auxiliary power reservoir based on the blimp type airship, stream-lined, and with an air bag for holding the shape of the bag. This would involve considerable added expense, and it is doubtful if the rubber manufacturers would be willing to divert their attention to it, should the demand arise, unless the necessity was much greater than at present.

Potter Now Acting Director

John D. Ryan, Second Assistant Secretary of War and Director of the Air Service, has appointed his assistant, William C. Potter, acting Director of Aircraft Production, during his absence. Mr. Ryan, it is believed, will appoint his permanent successor upon his return from France.

Completing Air Mail Plans

The Aerial Mail Division of the Post Office Department, under Second Assistant Postmaster General Otto Praeger, and Captain B. B. Lipsner, Superintendent of the Air Mail, is now completing plans for the opening of the airway mail route from New York to Chicago. Regular daily service will be instituted as soon as landing fields can be put into shape, with complete hangars and equipment.

The route to be followed will, in the main, be that taken by Pilot Edward V. Gardner and Pilot Max Miller in their test flights of September 6, 7 and 9. A slight deviation from the direct air route will have to be made at Lock Haven, Pa., where the first stop was planned. It has been found that the mountains of this region do not make a suitable air highway. The regular route to be undertaken will probably pass somewhat south of Lock Haven. Stops at Cleveland and at Bryan, Ohio, will form a part of the daily schedule.

While no definite date has as yet been set for the commencement of regular delivery, all possible speed is being made, as Captain Lipsner and the department are determined that regular service shall be in force before the winter months set in.

The landing of the postal airplane at New York on September 11, incidentally, recorded the first trip ever made by an airplane from Chicago to New York in a single day. The numerous attempts heretofore to make this flight have encountered interruptions which have prevented the completion of the trip until the succeeding day.

Pilot Gardner, accompanied by Edward Radle, mechanician, left Chicago at 6.25 a. m. in a plane propelled by a Liberty engine, and landed at Hicksville, L. I., at 8.20 in the evening. Allowing for one hour's difference in time and for stops made for replenishing of gas and oil, the trip from Chicago was made in 12 hours and 55 minutes. The actual flying time, however, was 10 hours and 5 minutes, there being a delay of 1 hour and 57 minutes at Cleveland and another 53 minutes at Lock Haven, Pa., for gas and oil.

A denial has been made by the Post Office Department of the published story that a Washington to Boston via New York air mail is soon to be set in operation. No such step is contemplated at present.

Forty Air Squadrons Authorized

The organization of forty air squadrons has been authorized by the War Department. Of these four will be located at Houston, Texas, and the balance of thirty-six, or a training brigade of three wings, on Long Island, N. Y.

As now planned, the base of the Long Island Training Brigade will be Hazelhurst Field, near Mineola. The squadrons will be quartered in groups of four on nine outlying fields, and will serve under field conditions simulating as nearly as practicable the conditions behind the lines in France. They will train as organizations, and it is hoped to furnish them completely with personnel and equipment so that when they have finished their training in the brigade very little additional training will be required and they may be sent to France in complete squadrons instead of in detachments as heretofore.

Air Service Stenographers Wanted

So rapidly has the Department of Military Aeronautics grown since its reorganization that it already has over 1000 civilian employes, in addition to officers and enlisted men.

A call has been issued to the public for thirty additional stenographers and fifty additional typists. A particular need of the Department is for stenographers who are qualified to take dictation in both French and English and make transcription accordingly. Applicants should call upon or address the Civilian Personnel Officer, Department of Military Aeronautics, Building D, Sixth and B Streets, N. W., Washington, D. C.

Non-Competitive Aeronautical Positions

An executive order was issued on August 21 amending Paragraph one, Schedule 13, Subdivision IV, War Department, by adding aeronautical mechanical engineers to the classified positions which may be filled upon non-competitive examination.

As amended, the paragraph reads: "1. Aeronautical engineers, aeronautical mechanical engineers, aeronautical chemists, instructors in flying, aviation mechanicians, inspectors of airplanes and airplane engines, and aeronautical mechanical draftsmen in the aviation section of the Signal Corps."

Optical Glass Problem Solved

Some of the fundamental items required by the Army and Navy in war times are technical in nature and would ordinarily not be thought of by the casual observer. Such an item is optical glass, which is used in telescopes and instruments that serve in the direction and control of firing large and small guns and in engineering and surveying operations. The artilleryman without fire-control instruments can accomplish little; the submarine without its periscope is of small value; the airplane without a camera can make no maps of the enemy's country. Therefore, optical glass is very essential in military instruments of different types.

To meet this situation, the Ordnance Department of the Army is establishing in Rochester, N. Y., a training school for operatives on precision optics. The school is to be located at the Mechanics Institute, in Rochester, and the large optical manufacturing firms in Rochester are providing instructors and aiding in the installation of the necessary grinding, polishing and centering apparatus.

Courses in the different branches of this industry will be given and extended over a period of six weeks. A living wage will be paid to those who take these courses. On completion of the course the student will be in a position to enter one of the optical munition factories and be competent to perform certain of the operations required.

Details regarding the courses of instruction can be obtained from Dr. Barker, president of the Mechanics Institute, Rochester, N. Y. The largest factories are located in Rochester, N. Y.; Boston and Southbridge, Mass.; Pittsburg, Pa., and Dayton, Ohio.

Air Department Bill

The bill to create an executive department in the Government, to be known as the Department of Aeronautics, has been favorably reported to the Senate by the Committee on Military Affairs. This is the bill introduced by Senator Harry S. New of Indiana.

The approval of Senator New's measure follows closely on the refusal of Acting Secretary of War Crowell to give the bill the endorsement of the War Department. "The organization of a Department of Aeronautics, separate and distinct from the War Department and containing military activities not under the control of the Secretary of War," declared Mr. Crowell, "is believed to be essentially wrong in principle."

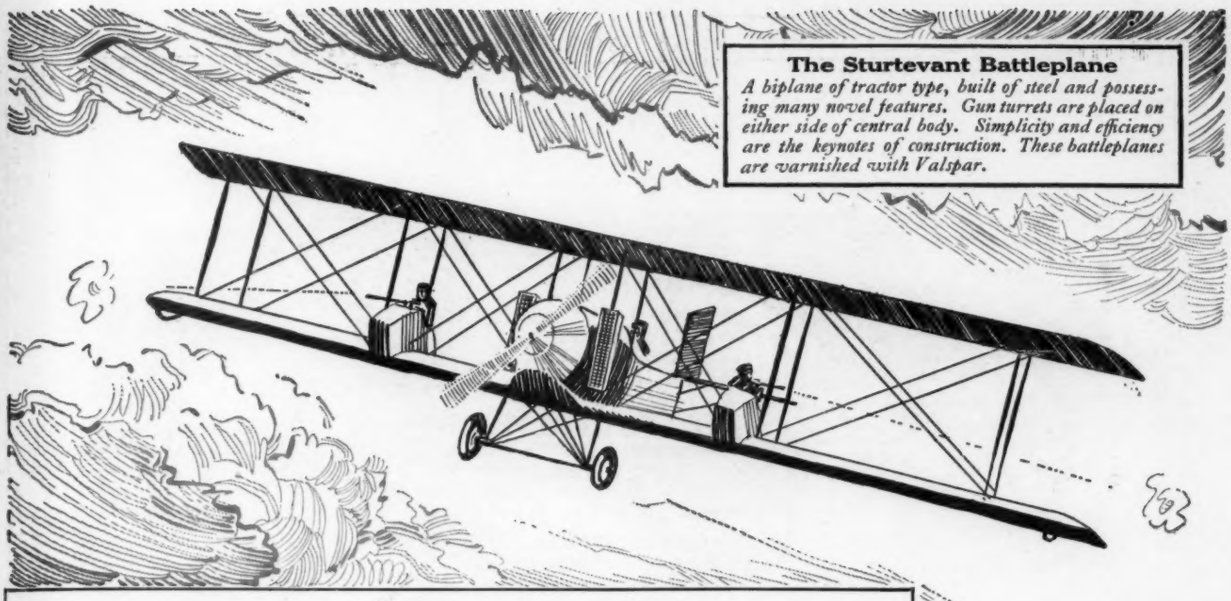
Yet the Senate Committee on Military Affairs, by a vote of 11 to 2, turned in a favorable report, eliminating, however, that clause of the original measure which would give the head of the proposed department a seat in the President's Cabinet. A provision was inserted giving the President authority to transfer to the Department of Aeronautics powers now vested in other departments pertaining to the Air Service, and "such personnel necessary for its operations."

As finally agreed upon, the department is created for the period of the war and for one year thereafter. The head of the department, to be appointed by the President, will receive a salary of $12,000 a year and shall have "direct and complete control of all matters pertaining to the designing, purchase, manufacture, production and operation of aircraft," not only for the Army, but also the Navy and Marine Corps.

Wright-Martin Employes Celebrate

More than 500 men and women, employes of the Wright-Martin Aircraft Corp., at their Long Island City plant, recently joined in a patriotic demonstration. The program was directed by Charles E. Mack, of the bureau, assisted by E. G. Pratt. The assemblage was in one of the big new buildings, capable of housing nearly 1000 men at work, which is being completed for the company under special requisitions given by the Government.

George Houston, president of the Wright-Martin Co., announced that his company has furnished the United States Government with 3000 engines, and that the Government has now made demand for more than three times that number, to be completed before the summer of 1919. Captain A. P. Simmons, formerly of the 18th Regulars, said the workers of the industrial army were as essential as the men in the trenches. Congressman Charles Pope Coldwell, of the Second District, who prepared the draft of the bill providing for the $640,000,000 for aircraft production, told of the necessity for rushing supplies needed by the army and the aero squadrons.



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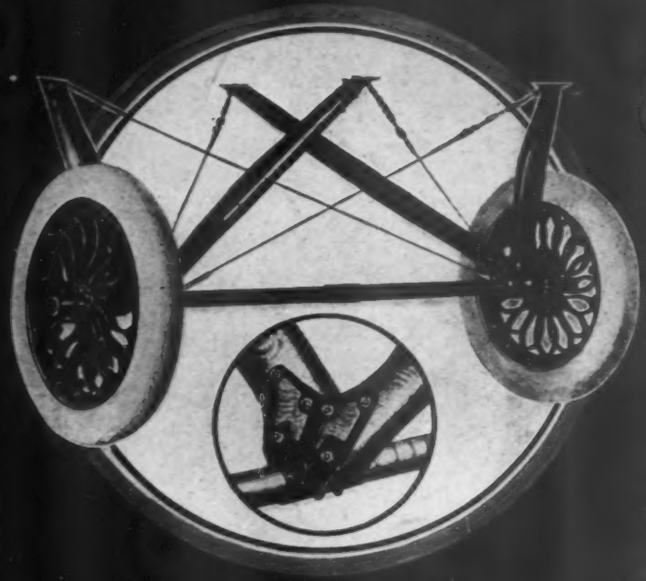
Let us figure on your next specifications.
We have managed to "take care" of some
very large concerns both in price and delivery

HAMMACHER, SCHLEMMER & CO.

HARDWARE, TOOLS AND SUPPLIES

New York, Since 1848 **4th Ave. and 13th St.**



ACKERMAN LANDING GEAR

Is the latest and highest development in the construction of Landing Gear

Built for

SIMPLICITY
STRENGTH
and SERVICE

make them the logical equipment for the Modern Airplane.

Weight 96 pounds complete with tires built for craft weighing 2500 pounds

WHEELS and LANDING GEARS built for any size machine

Complete data on Ackerman Equipment is available for Designers and Engineers.

THE ACKERMAN WHEEL COMPANY
542 Rockefeller Building, CLEVELAND, OHIO, U.S.A.

Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of companies listed below.

Names of Advertisers in this issue are printed in capitals.

See Index to Advertisers on page 328

ACCESSORIES AND INSTRUMENTS

Advance Felt Specialty & Cutting Co.
International Aeronautical Instrument Corp.
JOHNS-MANVILLE, H. W., CO.
King, Julius, Optical Co.
THE MOTO-METER CO.
National Gauge & Equipment Co.
Nelson Blower & Furnace Co.
O'Hara Waltham Dial Co.
Queen-Gray Co.
Ricker, Walter.
SPERRY GYROSCOPE CO.
Standard Aeronautical Co.
Stewart-Warner Speedometer Corp.
TAYLOR INSTRUMENT COMPANIES
VEEDER MFG. CO.
Western Electric Co.

AIRPLANES

Aeromarine Plane and Motor Co.
Blackhawk Airplane Co.
Blanchard-Radley Aircraft Co.
BOEING AIRPLANE CO.
Breese Aircraft Corp.
THE BURGESS COMPANY.
California Aviation Co.
Continental Aircraft Corp.
CURTISS AEROPLANE & MOTOR CORP.
DAYTON-WRIGHT AIRPLANE CO.
Des Lauriers Aircraft Corp.
Dewey Aeroplane Co.
Engel Aircraft Co.
Fisher Body Corp.
Fowler Airplane Corp.
Gallaudet Aircraft Corp.
Heinrich, A. S., Corp.
Lanzius Aircraft Co.
Lawrence-Lewis Aeroplane Co.
Lawson Aircraft Corp.
Lewis & Vought Corp.
Lanzius Aeronautical Eng. Corp.
Longren Aeroplane Co.
L. W. F. ENGINEERING CO.
Martin Aeroplane Factory
MARTIN, GLENN L., CO.
Michigan Aircraft Corp.
Ordnance Eng'ring Corp.
Patterson Aeroplane Co.
Peirce, Sam'l S., Aeroplane Corp.
Rubay Co.
St. Louis Aircraft Co.
Smith, Kyle, Aircraft Co.
Sperry, Lawrence, Aircraft Co.
Springfield Airplane Co.
STANDARD AIRCRAFT CORP.
Sturtevant Aeroplane Co.
THOMAS-MORSE AIRCRAFT CORP.
The Willys-Morrow Co.
WITTEMANN-LEWIS AIRCRAFT CO.
Whittemore-Hamm Co.
Wright-Martin Aircraft Corp.

AIRPLANE ENGINES

Aeromarine Plane and Motor Co.
Ashmusen Mfg. Co.
Continental Motors Co.
CURTISS AEROPLANE & MOTOR CORP.
Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP.
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
HALL-SCOTT MOTOR CAR CO.
Kemp Machine Works.
Kessler Motor Co.
Knox Motors Co.
Nordyke & Marmon.
Packard Motor Co.
Roberts Motor Mfg. Co.
Rolls-Royce, Ltd.
Springfield Motors Co.
Sterling Engine Co.
Sturtevant, B. F., Co.
Trego Motors Corp.
THOMAS - MORSE AIRCRAFT CORP.
UNION GAS ENGINE CO.
Van Blerck Motor Co.
Willys-Overland Co.
WISCONSIN MOTOR MFG. CO.
World's Motor Co.
Wright-Martin Aircraft Corp.

AIRPLANE PARTS

Aircraft Parts Mfg. Co.
American Body Co.
Astoria Veneer Mill & Dock Co.
BARCALO MFG. CO.
Century Telephone Construction Co.
Chicago Aeronautical Supply Co.
Dayton Metal Products Co.
ERIE SPECIALTY CO.
General Aluminum & Brass Mfg. Co.
GENERAL BAKELITE CO.
HOLBROOK CO.
Kawneer Mfg. Co.
Levett, Walker M., Co.
New Jersey Veneer Co.
Pressed & Welded Steel Products Co.
Rogers Construction Co.
Standard Parts Co.
Welch Mfg. Co.
Whittemore-Hamm Co.
WIDMAN, J. C., & CO.
Willys-Morrow Co.
Wilson Cabinet Co.

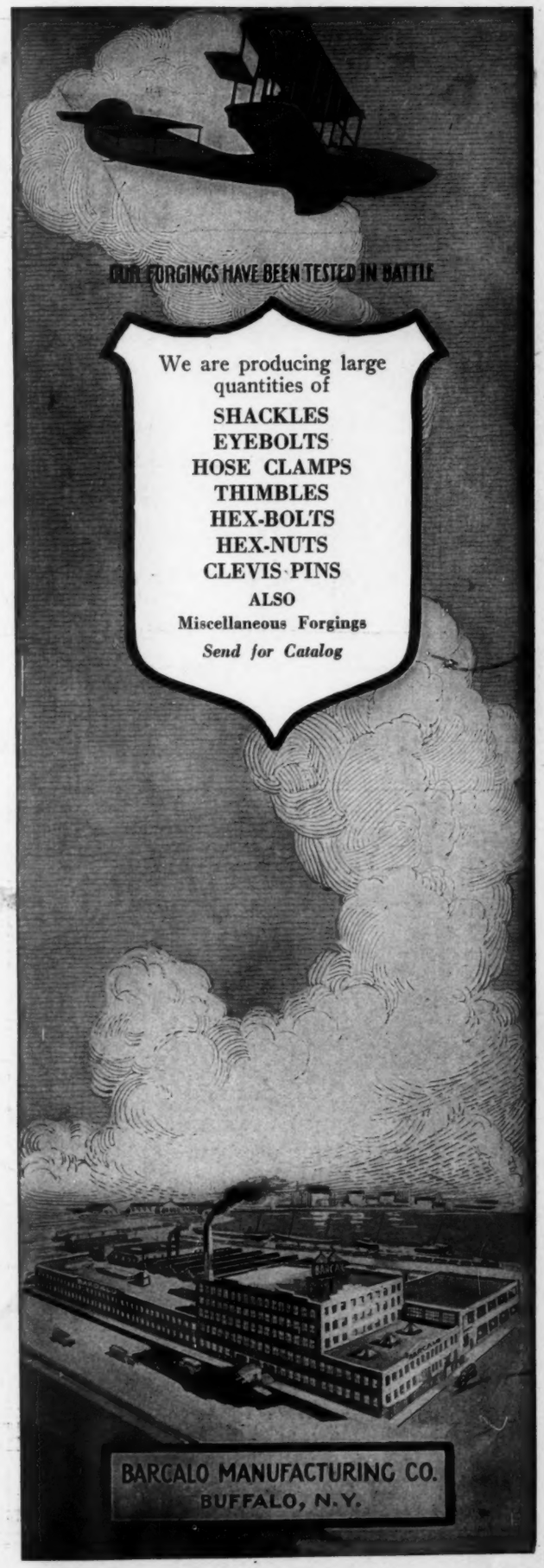
ALUMINUM

Acieral Co. of America
Aluminum Castings Co.
ALUMINUM CO. OF AMERICA
American Metal Co., Ltd.
General Aluminum & Brass Mfg. Co.
Levett, Walker M., Co.
Leygrand & Co.
McAdamite-Aluminum Co.
SO-LUMINUM MFG. & ENG. CO. (SOLDER)
STIMPSON, EDWIN B., CO.
United Smelting & Aluminum Co.

AVIATION SCHOOLS

EAGLE AVIATION SCHOOL
Michigan State Auto School
Morris-Bud Airplane School
Penn. State School of Aero-Mechanics
West Side Y. M. C. A.
Whittemore-Hamm Co.

(*Continued on page 317*)



YALE
TRADE MARK

HOISTING HINTS

Yale Spur-Geared Block hoisting large gear wheel

Hoist Quick!

It's *easy* to do with a Yale Spur-Geared Block.

Handling heavy and hard hoisting—with speed and safety—is a Yale feature.

Speedy because of its design—*Safe* because of its steel construction.

In War work especially, where "top notch" methods are vital, Yale Spur-Geared Blocks easily show their great worth.

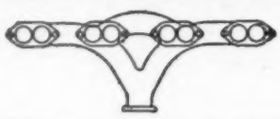
Sold by Machinery Supply Houses

Send for Catalog

For factory locking equipment use a Yale Master Keying System. Write for particulars.

The Yale & Towne Mfg. Co.
9 East 40th Street New York

AJAX Auto and Aero Sheet Metal Company
Manufacturers and designers of
AERO RADIATORS INTAKE and EXHAUST PIPES
H. W. MEYER, 245 West Fifty-fifth Street, New York



Johns-Manville

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

Aeronautic Instruments

OUR designing staff and manufacturing organization are both at the call of those who require *speed indicating* and *revolution recording* instruments.

We invite your special problems in airplane accessory apparatus.

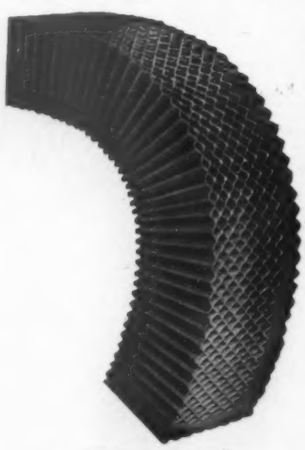
H. W. Johns-Manville Co.
New York City

10 Factories. Branches in 60 Cities

"Flexo" Aero RADIATORS

The only core that will stand severe landing shocks.

No sharp corners to crystallize through vibration.



The only core that can be so bent without injury to the metal or soldered joints.

"FLEXO"—PATENTED

FLEXO MANUFACTURING CO.

1313-1330 E. 12th STREET LOS ANGELES, CAL.

Aeronautical Trade Directory—*Continued*

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Gurney Ball Bearing Co.
Hess-Bright Mfg. Co.
NEW DEPARTURE MFG. CO.
NORMA COMPANY OF AMERICA
S. K. F. Ball Bearing Co.
U. S. Ball Bearing Mfg. Co.

BALLOONS: DIRIGIBLES

Bardette Oxygen Co.
Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
Gas Engineering Co. (Gas Plants)
GOODYEAR TIRE AND RUBBER CO.
United States Rubber Co.

BAROGRAPHS AND BAROMETERS

Green, Henry J.
International Aeronautical Instrument Corp.
Sussfield & Lorch
TAYLOR INSTRUMENT COMPANIES

BEARING METALS

Aluminum Castings Co.
AMERICAN BRONZE CORP.
FAHRIG METAL CO.
General Aluminum & Brass Mfg. Co.
Levett, Walker M., Co.
Magnolia Metal Co.

BUSHINGS

Aluminum Castings Co.
AMERICAN BRONZE CORP.
Bound Brook Oil-less Bearing Co.

CARBURETORS

H. & N. Mfg. Co.
Master Carburetor Co.
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler & Schebler
ZENITH CARBURETOR CO.

CLOCKS AND WATCHES

Chelsea Clock Co.
Depollier, J., & Son
Hamilton Watch Co.
Ingersoll, Robert H., & Bros.
Waltham Watch Co.

CLOTHING

Abercrombie & Fitch
Cross, Mark
N. Y. Sporting Goods Co.
Rainwear Co.
Rogers, Peet & Co.
Sanders Company
Spalding, A. G., & Bros.

COMPASSES

SPERRY GYROSCOPE CO.
Star Compass Co.
TAYLOR INSTRUMENT COMPANIES

DOPE AND VARNISH

Adams & Elting Co.
American Emaillite Co.
BROOKLYN VARNISH MFG. CO.
Certus Cold Glue Co.
Chemical Products Co.
Conover, The C. E., Co.
DU PONT CHEMICAL WORKS
Flexible Compound Co.
Harland, Wm., & Son
Howe Varnish Co.
Lucas, John, Company
Masury, John W., & Son
Perry-Austen Company
PRATT & LAMBERT
Sherwin-Williams Co.
Smith, Edward, & Co.
Standard Varnish Works
VALENTINE & COMPANY
Weeks & Co.

DRIFT INDICATOR

SPERRY GYROSCOPE CO.

DRY KILNS

Cutler Dry Kiln Co.
Drying Systems, Inc.
Grand Rapids Veneer Works

DYNAMOMETER

Sprague Electric Works

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Allegheny Forging Co.
Aluminum Castings Co.
Anderson Forge & Machine Co.
BARCALO MFG. CO.
Brooks Machine Co.
Burd High Compression Ring Co.
Crosby Steam Gage & Valve Co.
Dallet, Thos. H., Co.
DOEHLER DIE CASTING CO.
ERIE SPECIALTY CO.
Fibre Finishing Co.
General Aluminum & Brass Mfg. Co.
Gifford, Leland, Co.
Gill, P. H., & Sons
Hayes Mfg. Co.
Hydraulic Pressed Steel Co.
Levett, Walker M., Co.
Meisel Press Mfg. Co.
PARK DROP FORGE CO.
Pressed & Welded Steel Products Co.
Standard Parts Co.
STIMPSON, EDWIN B., CO.
Taft-Peirce Mfg. Co.
Tioga Steel & Iron Co.
Williams, J. H., & Co.
Whitman & Barnes Mfg. Co.
WYMAN-GORDON CO.

ENGINEERING

AUTOMOTIVE ENGINEERING CO.
Ordnance Engineering Co.
White, J. G., Engineering Corp.

FABRICS

Courtral Mfg. Co.
Hutchinson, Scott Co.
Lamb, Finlay & Co.
McBratney, Robt., & Co.
Whitman, Clarence & Co.

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Booth Felt Co.
Western Felt Works

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JOHNS-MANVILLE, H. W., Co.
Pyrene Mfg. Co.

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BOSTON AUTO GAUGE CO.
Crosby Steam Gauge & Valve Co.
FOXBORO CO., INC.
Greenfield Tap & Die Corp.
United States Gage Co.

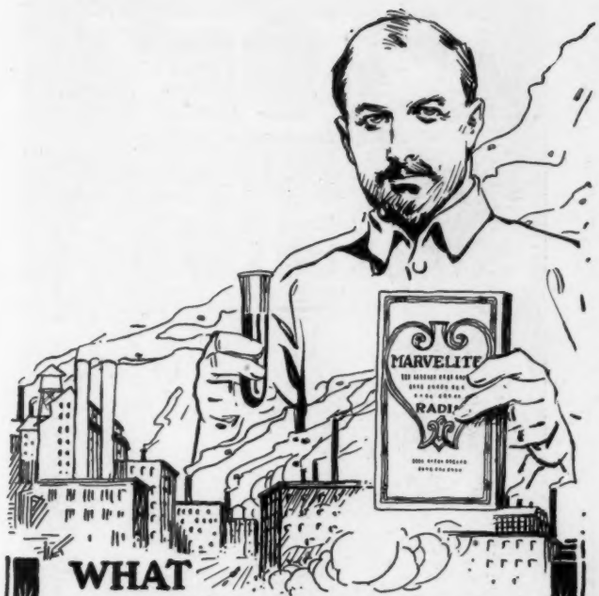
GASKETS

Advance Felt Specialty & Cutting Co.
Booth Felt Co.
Fibre Finishing Co.

GLUE

Armour Glue Works
Baeder & Adamson
Certus Cold Glue Co.
Ferdinand, L. W., & Co.
WIDMAN, J. C., CO.

(*Continued on page* 319)



WHAT LABORATORY GENIUS HAS DONE FOR YOUR BUSINESS

Made it possible for you to use RADIUM for all sorts of practical purposes. Pure Radium is combined, by our secret processes, with a responsive base, and the resulting compound glows steadily at night for practically a life-time. The name of our product is

MARVELITE

It makes clearly visible in the dark everything to which it is applied

Used on Watches, Clocks, Aircraft, Ship and Automobile Instruments. Over half a million instruments have been Marvelited for the government during the past year.

How we co-operate with the manufacturer

The uses of Marvelite are just beginning to be understood. You undoubtedly manufacture some instruments or articles which would be of greater use and value if they could be seen in the dark.

Our Laboratory is at your service, without charge, for experimental purposes, and we will work with you to solve your problem. Tell us what it is.

Send for booklet "A" for information of value to users of self-luminous compounds. Many mistakes may be avoided by using the knowledge gained from this book, as to the character of luminous material best suited to your particular case. Marvelite is made in several different grades. Sometimes the highest grade is required, and under other conditions a lower grade gives better results and costs less.

Do you know which kind to use?

COLD LIGHT MANUFACTURING CO.
558 West 158th Street, New York

BUY LIBERTY BONDS

Indian Motocycle

HENDEE MANUFACTURING COMPANY

(Largest Motorcycle Manufacturers in the World)

767 STATE STREET SPRINGFIELD, MASSACHUSETTS

WEST WOODWORKING COMPANY

(Patent Pending)

Manufacturers of

Westmoore Propellers
Swesco Wing Beams
Waterproof Plywood Panels
Laminated Construction for All Parts

Highest Quality
Quantity Production
Prompt Shipments

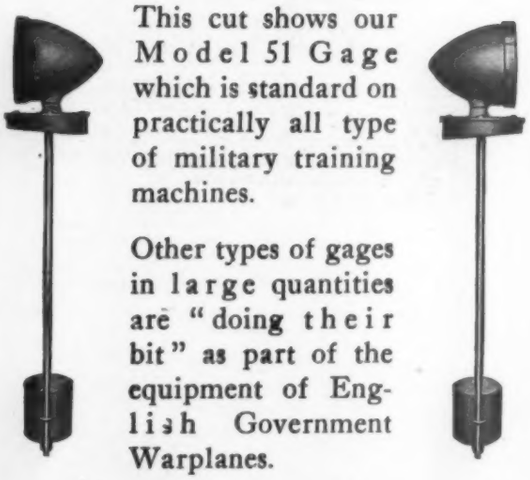
Address:

WEST WOODWORKING COMPANY
308-324 N. Ada Street Chicago

Cable address "SWESCO"

Cabinet makers with over thirty years' successful business behind them

FUEL LEVEL GAGES



This cut shows our Model 51 Gage which is standard on practically all type of military training machines.

Other types of gages in large quantities are "doing their bit" as part of the equipment of English Government Warplanes.

SPECIAL TYPES DESIGNED FOR YOUR ESPECIAL NEEDS.

BOSTON AUTO GAGE CO.

8 WALTHAM STREET, BOSTON, MASS.

ROME AERONAUTICAL RADIATORS

Developed from years of experience in building all types of radiators.
They possess every feature and qualification necessary for a high grade product.

STRONG
EFFICIENT
DURABLE

Used on the best American flying machines.
Our engineering department is at your service.

Rome-Turney Radiator Company
Rome, N. Y., U. S. A.

Aeronautical Trade Directory—*Continued*

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Hardy, F. A., Co.
Meyrowitz, E. B.
STRAUSS & BUEGELEISEN
Strong, Kennard & Nutt
Triplex Safety Glass Corp.
Willson, T. A., & Co., Inc.

HANGARS

American Bridge Co.
Anchor Corrugating Construction Co.
Ashley Steel Bldg. Co.
Austin Co., The
Barney, John M.
Howell, Field & Goddard, Inc.
Keasby & Mattison
Milliken Brothers
Pruden, The C. D., Co.
Steel Fabricating Co., The
Virginia Bridge & Iron Co.

HOISTS

Yale & Towne Mfg. Co.

IGNITION

Philips-Brinton Co., The

LIFE PRESERVERS

Robinson-Roders Co.
Universal Safety Mattress Co.

LUMBER

Alcock Co., John L.
American Balsa Corp.
Astoria Veneer Mills & Dock Co.
Chetham Lumber Co.
Delatour, J.
Dutton, A. C., Lumber Corp.
Ludlow, Israel
Mengel, C. C., & Bros. Co.
New Jersey Veneer Co.
Sheip & Vandergrift

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COLD LIGHT MFG. CO.
Cummings, W. L., Chemical Co.
RADIUM DIAL CO.
RADIUM LUMINOUS MATERIAL CORP.

MACHINERY, METAL WORKING

DALTON MFG. CORP.
DEFIANCE MACHINE WORKS
FOX MACHINE CO.
Warner & Swasey Co.

MACHINERY, WOOD-WORKING

Curtis Machine Corp.
DEFIANCE MACHINE WORKS
Fay, J. A., & Egan Co.
FOX MACHINE CO.
Machinery Merchants, Inc.
MATTISON, C., MACHINE WORKS
Olney & Warrin
Pryibil, P., Machine Co.
YATES, P. B., MACHINE CO.

MAGNETOS

Berkshire Magneto Corp.
Bosch Magneto Co.
ERICSSON MFG. CO.
Remy Electric Co.
Splitdorf Electrical Co.

MANIFOLDS

AJAX AUTO & AERO SHEET METAL CO.
Pressed & Welded Steel Products Co.

METALS

Acieral Co. of America
American Bronze Corp.
American Vanadium Co.
Bethlehem Steel Co.
BETZ-PIERCE CO., THE
BLUM, JULIUS & CO.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gueder, Paeschke & Frey Co.
Kawneer Mfg. Co.
La Salle Steel Co.
Levett, Walker M., Co.
Rumford Metal Co.
SO-LUMINUM MFG. & ENG. CO.
Standard Alloys Co.
Steel Sales Corp.
Steel Products Co.
STIMPSON, EDWIN B., CO.
Wheeler, Frank H., & Son

MODEL AIRPLANES

Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES

Excelsior Motor Mfg. Supply Co.
HENDEE MFG. CO.
Harley-Davidson Co.
Militare Motor Vehicle Co. of America

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Baker Castor Oil Co.
Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co.
Sun Co., The
Standard Oil Co.
Swan & Finch
Texas Co., The
Vacuum Oil Co.
Wakefield, C. C., & Co., Ltd.

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Booth Felt Co.
Fibre Finishing Co.

PHOTOGRAPHY

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Herbert & Huesgen Co.

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Levett, Walker M., Co.

PISTON RINGS

American Piston Ring Co.

PONTOONS

Niagara Boat Co.
PALMER-SIMPSON CO.
Welin Marine Equipment Co.

PROPELLERS

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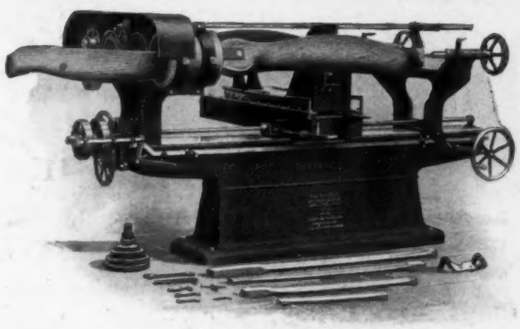
American Sash & Door Co.
Aviauto Mfg. Co.
Breitung & Co., Ltd.
C. M. O. Physical Laboratory
Doyle, W. A.
Hartzell Walnut Propeller Co.
JACUZZI BROS.
Jamestown Propeller Co.
Lang Propeller Co. of America
Steves Sash & Door Co.
Reinforced Propeller & Insulating Co., The
United States Aero Propeller Co.
Washington Aeroplane Co.
WEST WOODWORKING CO.

(*Continued on page* 321)

THE DEFIANCE AUTOMATIC AIRPLANE PROPELLER LATHE



IT HAS GOVERNMENT AND MANUFACTURERS' ENDORSEMENTS

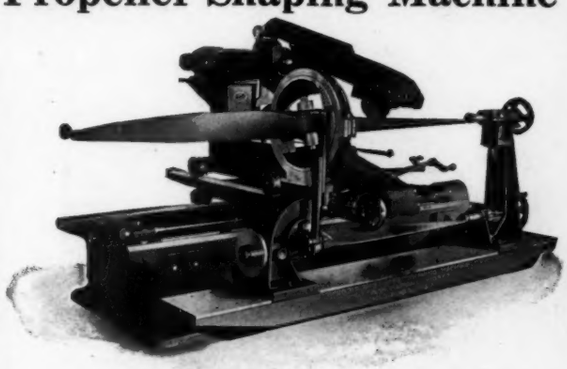
The proof of this lies in its use in England, in Italy, in Canada; its use in United States Government Arsenals, and fifteen of the leading propeller factories in America. Each machine in use releases from eight to ten skilled workmen for other duties. With one man operating a number of machines, the cost of working propeller blades close to size is reduced to a minimum. It automatically turns propeller blades of various sizes to any shape or pitch, and it will duplicate struts of irregular shape in facsimiles. Write for our circular which illustrates and describes this machine.

THE DEFIANCE MACHINE WORKS

DEFIANCE, OHIO, U. S. A.

NEW YORK *LONDON*

MATTISON
Propeller Shaping Machine



For Two, Three and Four-Bladed Screws

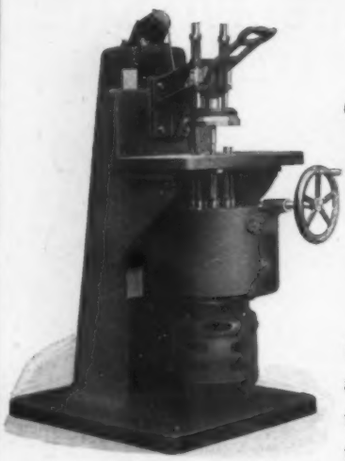
A brand new machine—designed and built with the thoroughness characteristic of all Mattison woodworking machines—which has been approved by many of America's largest propeller manufacturers.

It works close to finish-size, thereby eliminating the greater part of the expensive hand work which usually follows the machining operation of other methods.

Write or Wire for Details

MATTISON MACHINE WORKS

Rockford, Illinois, U. S. A.



Yates

Type C-20 Propeller Boring Machine

A recently perfected machine for automatically boring the necessary holes in the modern aeroplane propeller hub in one operation. Extremely durable, compact, and efficient. Does absolutely accurate and uniform work. Specially designed so that no oil can get on and injure the stock. Either belt or direct motor drive.

Send today for complete details

P. B. Yates Machine Co.
BELOIT, WISCONSIN, U. S. A.

The Very Stuff of Victory

The materialist has said buying Liberty Bonds signifies nothing.

He looks upon each issue as representing an investment which has no equal today in all the world.

Consequently, he views their purchase as involving no sacrifice nor deserving of credit. As far as his vision lets him see he is right. But unfortunate is he, indeed, who cannot look beyond the simple action and recognize the full power of the motive.

That these bonds are the greatest investment in the world may rightly be laid at the feet of good fortune, because they are *the promise-to-pay-with-interest of the greatest government in the world*, backed by the most tremendous resources in the world.

Such, however, is not the great overwhelming and impelling reason that millions of red-white-and-blue men and women now own billions of dollars of Liberty Bonds and in this Fourth Liberty Loan are subscribing for billions more.

The motive is a far deeper one. It transcends all material considerations and its fabric is the very stuff of victory.

For Liberty Bonds to the great host of American men and women represent work accomplished, thrift acquired, money saved and devoted without stint or limit to that greatest purpose which shall finally achieve victory over organized force inimical to the peace of the world.

So when your dollars are invested in United States Government Bonds of the Fourth Liberty Loan, though they are invested in the *most wonderful investment in the world*, they become more than ordinary dollars because they are then the concrete expression of a hallowed purpose and dedicated to its achievement, the very stuff of victory.

This Space Subscribed to Winning the War by

J. W. Wood Elastic Web Co.
Stoughton, Mass.

Fahrig Anti-Friction Metal

The Best Bearing Metal on the Market
A Necessity for Aeroplane Service

Fahrig Metal Quality has become a standard for reliability. We specialize in this one tin-copper alloy which has superior anti-friction qualities and great durability and is always uniform.

When you see a speed or distance record broken by Aeroplane, Racing Automobile, Truck or Tractor Motor, you will find that Fahrig Metal Bearings were in that motor.

FAHRIG METAL CO., 34 Commerce St., N. Y.

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of the

Highest Quality

to Meet the Most
Exact Requirements

Standard Turnbuckle Company
CORRY, PA.

New York Office: Woolworth Building

Aeronautical Trade Directory—*Continued*

PYROMETERS
FOXBORO CO., INC., THE
MOTO-METER CO.
Shore Instrument & Mfg. Co.
TAYLOR INSTRUMENT COMPANIES

RADIATORS
AJAX AUTO & AERO SHEET METAL CO.
A-Z Co.
Bush Mfg. Co.
El Arco Radiators Co.
English & Mersick Co.
FLEXO MFG. CO.
Harrison Radiator Co.
Livingston Radiator Co.
McCord Mfg. Co.
ROME-TURNEY RADIATOR CO.
Standard Roller Bearing Co.

RIVETS
STIMPSON, EDWIN B., CO.

SCELEROSCOPE
Shore Instrument & Mfg. Co.

SHEET METAL FITTINGS
BLUM, JULIUS & CO.
Rogers Construction Co.

SHOCK ABSORBERS
Dural Rubber Corp.
General Rubber Goods Co.
Ohio Rubber Co.
Russell Mfg. Co.
WOOD, J. W., ELASTIC WEB CO.

SPARK PLUGS
Bosch Magneto Co.
Champion Ignition Co.
Johns-Manville, H. W., Co.
Rajah Auto Supply Co.
Silvex Co., The
Splitdorf Electrical Co.

SPEED INDICATORS
FOXBORO CO., INC.
Johns-Manville, H. W., Co.
Stewart-Warner Speedometer Corp.

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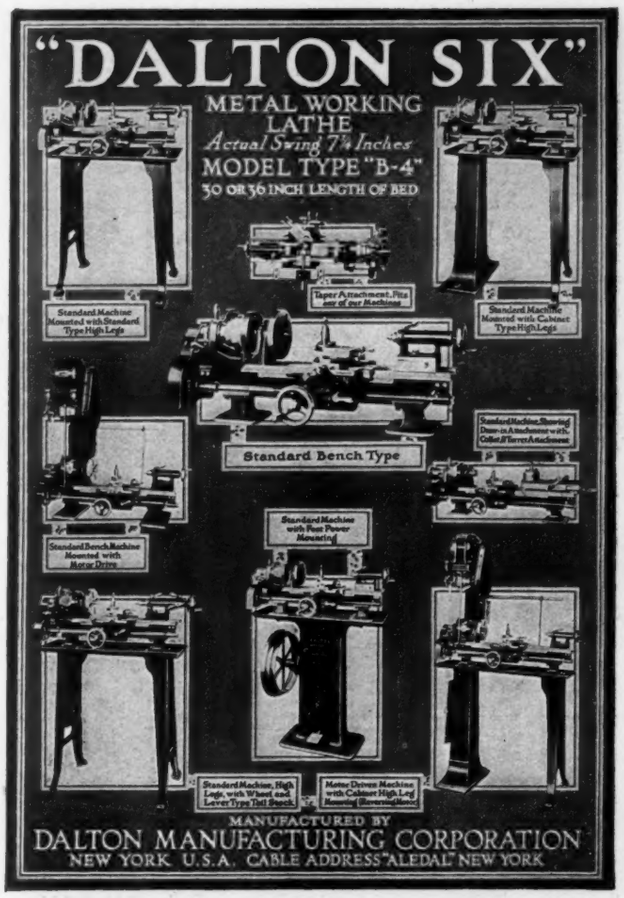

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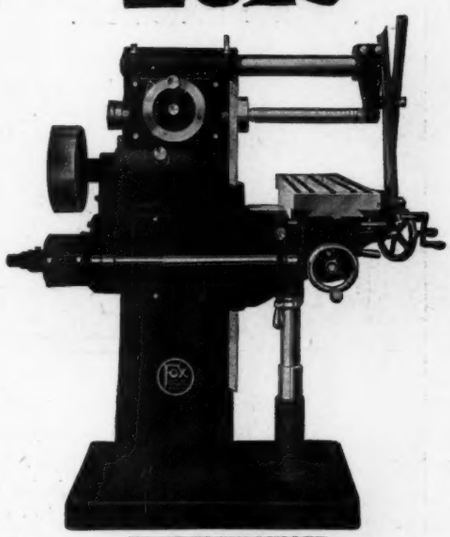

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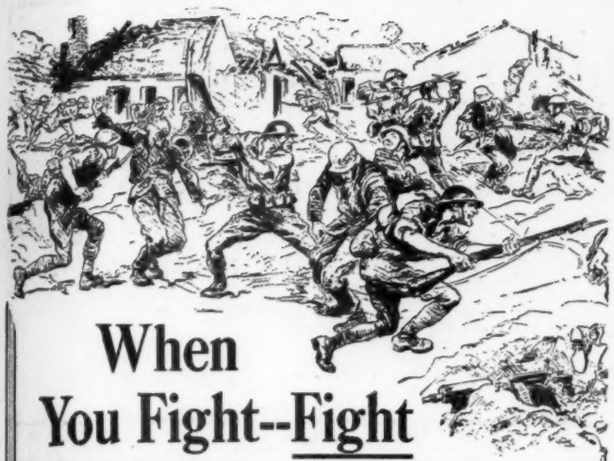

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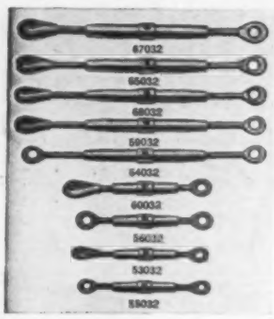

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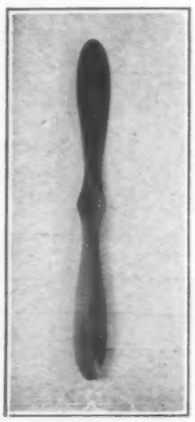
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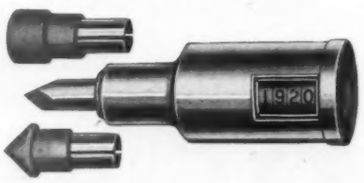

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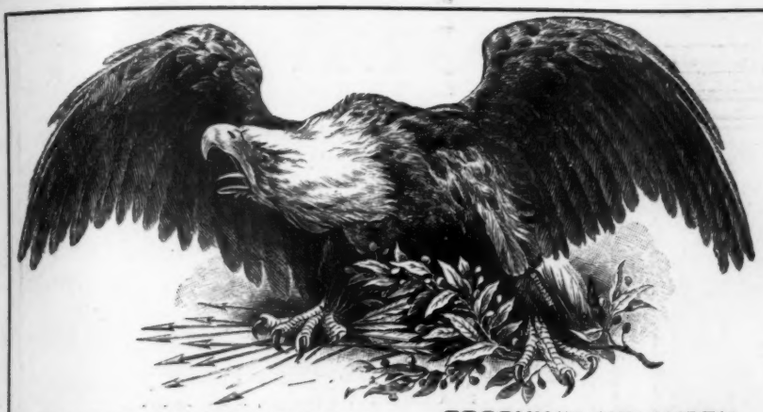

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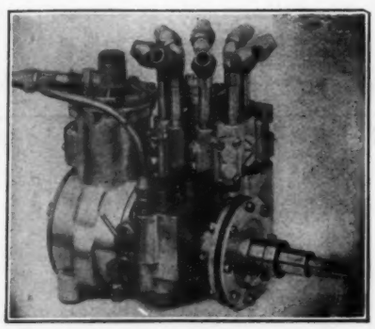

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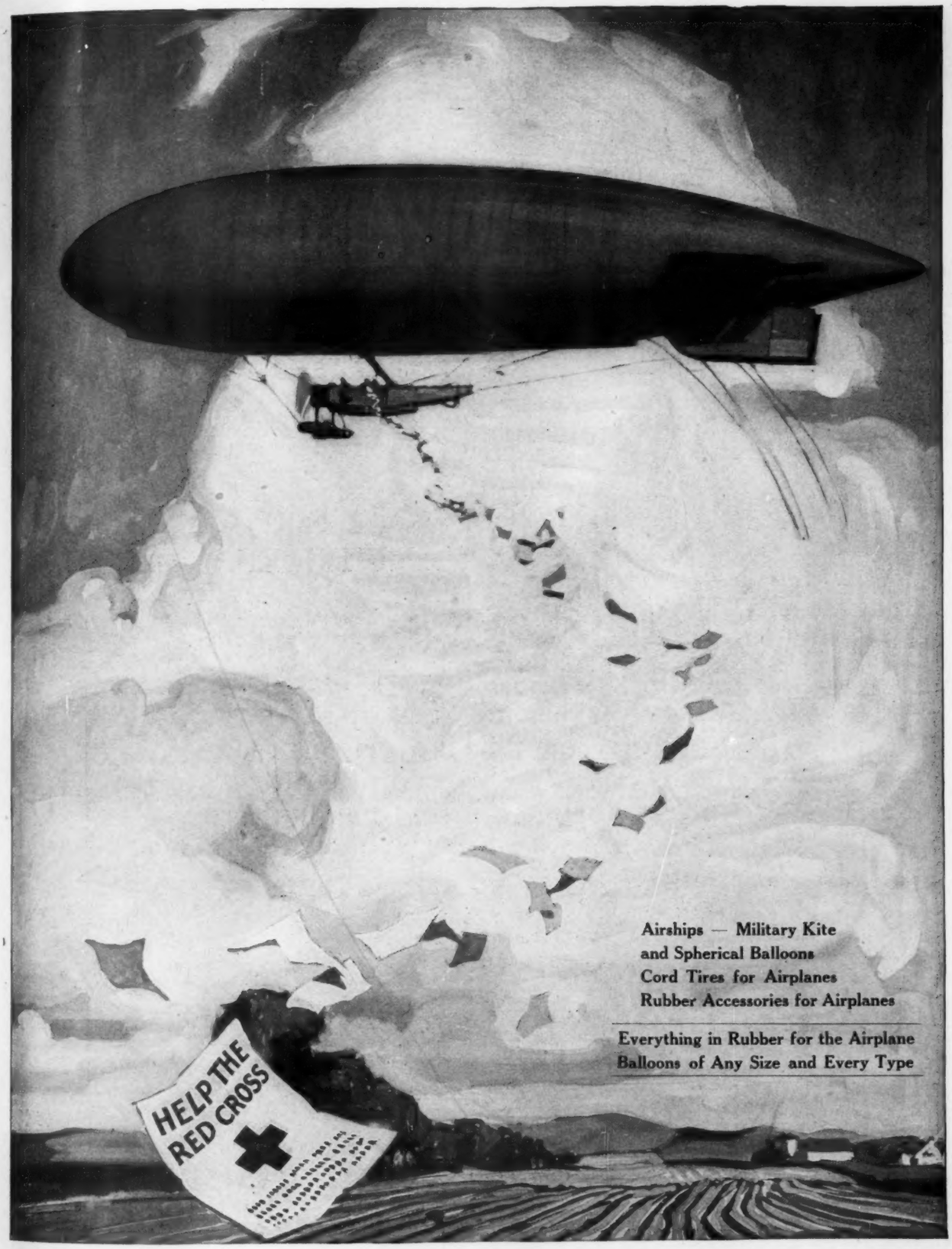

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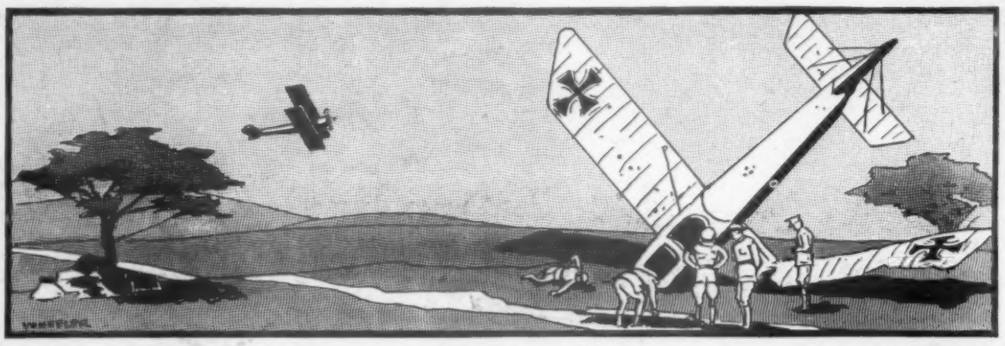

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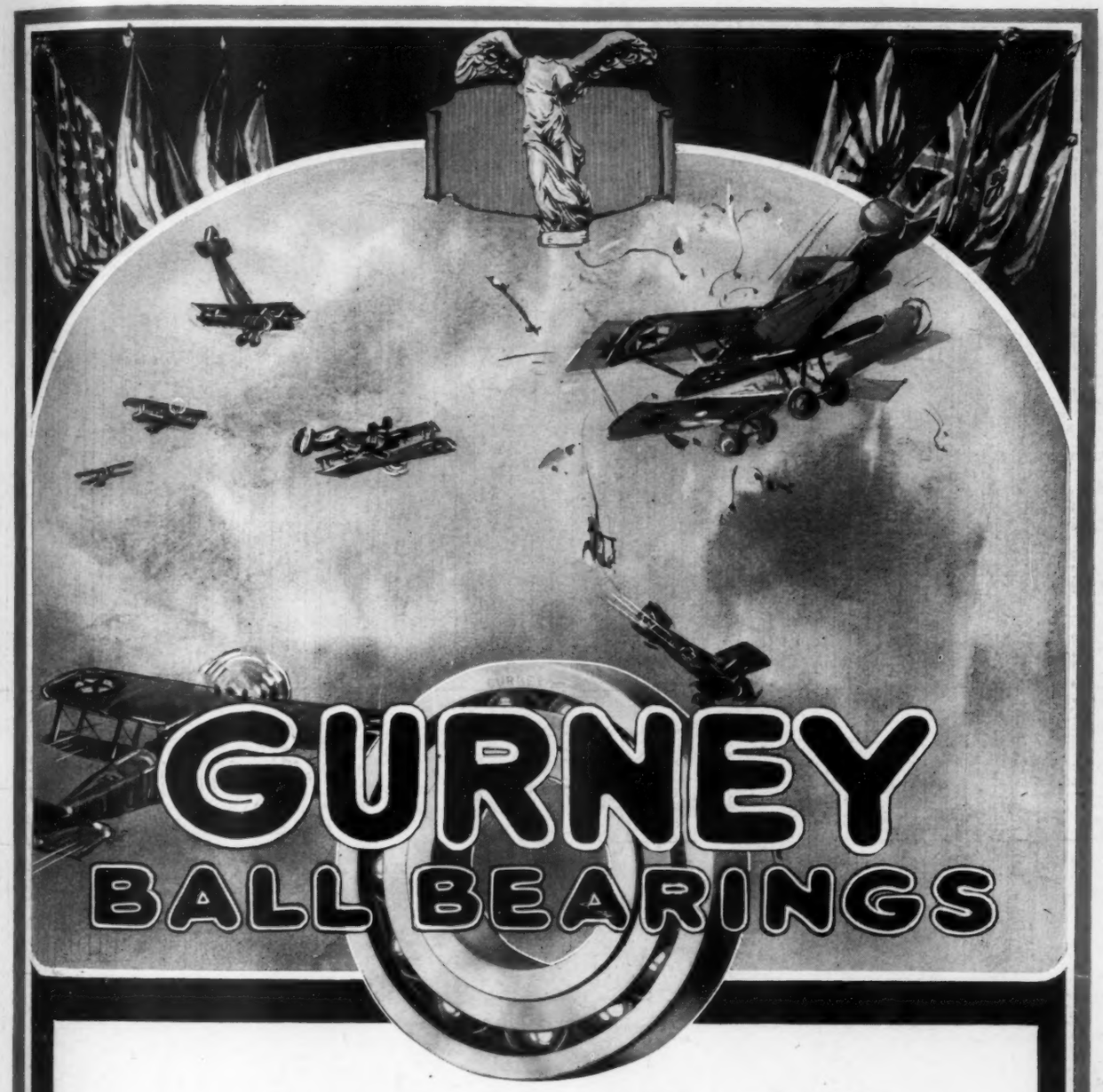

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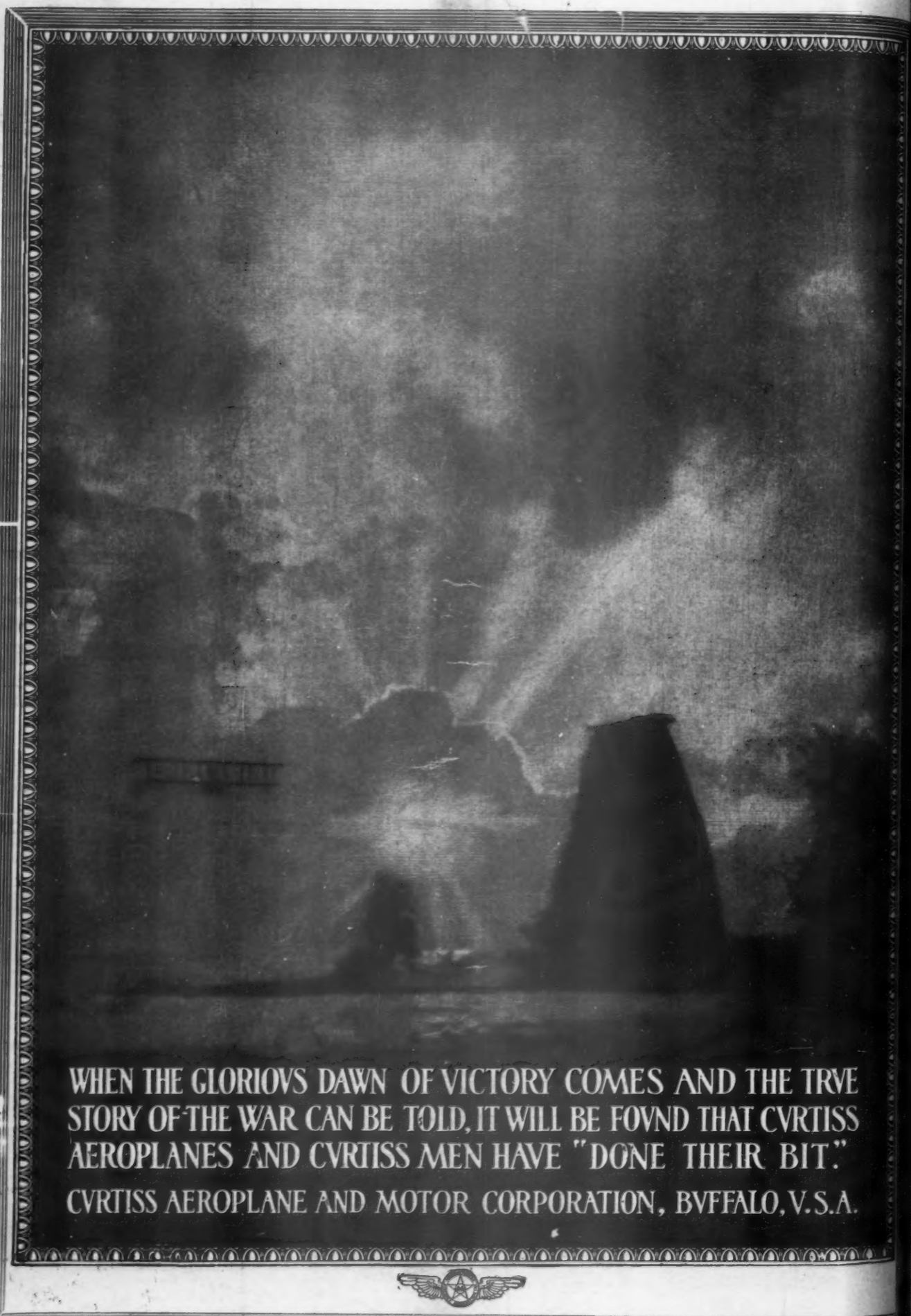
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